CAVES OF MOUNT ST. HELENS AND THE IMPACTS OF THE 1980 ERUPTIONS

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The Cave Basalt is the only known speleoliferous lava flow of Mount St. Helens. It dates to about 1950 years B.P. Some of its caves underwent extensive aggradation about 450 years ago, by two post-eruptive flash floods and/or mudflows. These deposits underwent extensive erosion and reworking prior to the 1980 eruptions. Two and possibly more of the 1980 eruptions caused significant vertical airfall of tephra in the cave area. An unusual sequence of mudflows and flashflood landforms developed, both above and below ground. Some caves and other subsurface spaces acted as conduits and/or sediment traps. Two caves and parts of others have been filled by 1980 and reworked pre-1980 deposits. In comparison with the recent events elsewhere on Mount St. Helens, however, the impact of the 1980 eruptions and post-eruption events has been spotty and comparatively minor. Some of the greatest impacts to date correlate with pre-1980 human activity.

INTRODUCTION

Prior to 1980, some geological, speleological and popular reports mentioned modification of certain pre-existing lava tube caves by later eruptive episodes, and a few discussed them on a deductive basis. For the first time, however, the 1980 and subsequent eruptions of Mount St. Helens have permitted sequential observation and measurement of spelean effects of a variety of peri-eruptional phenomena in an area of exceptional interest, significance and accessibility.

Under St. Helens Research Committee Permit #9, and successor permits, field parties of the Western Speleological Survey were permitted to begin studies of these effects on June 22, 1980. Several subsequent reports have been published as Bulletins of the Washington Speleological Survey, in *Geo*[2], in the Proceedings of the 8th International Congress of Speleology, and elsewhere. Despite ongoing bureaucratic obstruction of research discussed elsewhere (Halliday, 1981), studies are continuing here and in other types of pseudokarst on and around the volcano.

Significance of the area

The national and international significance of the Mount St. Helens cave area has been recognized for more than 20 years. Mention of Ole's Cave (as Spencer's Cave) appears in the international speleological literature as early as 1900 (Martel, 1900). For several years after its initial mapping in 1958, Ape Cave was considered to be the world's longest lava tube cave. Even today, it is the longest known on either American continent. Although almost entirely undeveloped, it is a very popular year-round public attraction. Several other caves in the area qualify as world-class according to the criteria of the International Union of Speleology, and numerous smaller caves here have major biological, geological, historical, recreational, wilderness, and other values (U.S. Senate, 1982; U.S. House of Representatives, 1982). In 1962, I urged creation of a Lava Caves National Monument here (Halliday, 1962). Subsequently, Pryde (1968) listed it as one of the three essential parts of a Mount St. Helens National Monument, a proposal currently well-received by Congress. (A bill creating a Mount St. Helens National Volcanic Monument was enacted by Congress, and signed into law by President Ronald Reagan in August 1982.)

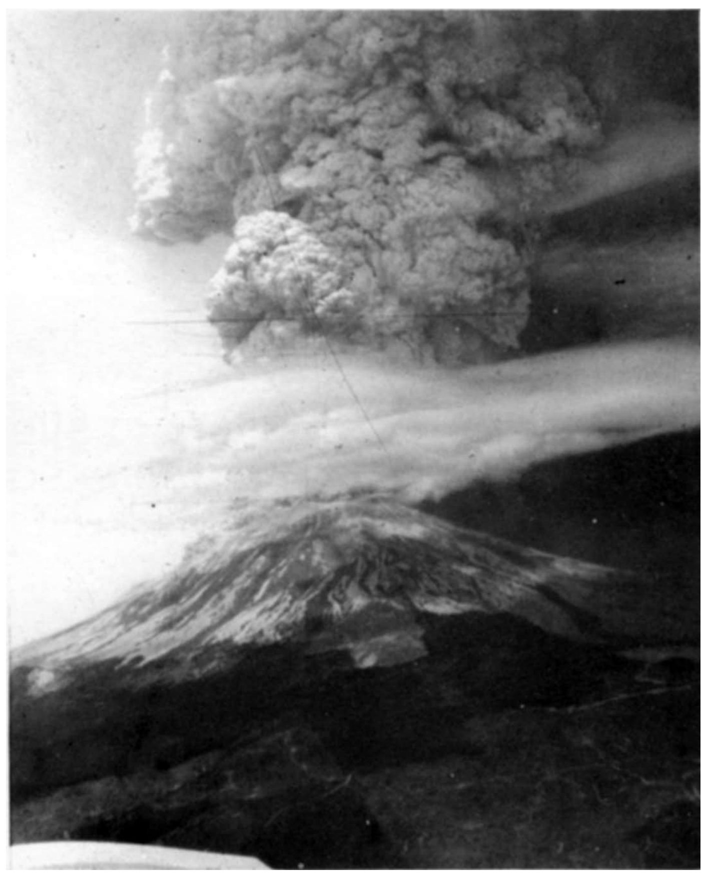

Figure 1. Commercial photo on May 18, 1980 shows that cave area was free of tephra fall during that eruption. Uppermost identifiable part of the Cave Basalt Flow is in the triangular clearcut in the lower left of that photo. Photo Vernon McCall.

Basic Geology of the Mount St. Helens Cave Area

The cave area of Mount St. Helens is on the gently-sloping lower slopes of the south-southwest quadrant of the volcano, at a distance of about five to twenty km from the rim of the 1980 crater. It is almost 180° away from the axis of the lateral blast of May 1980 and the pyroclastic flows which followed it. The

Figure 2. *Mount St. Helens area, August 6, 1981. Aerial photo courtesy of U. S. Geological Survey.*

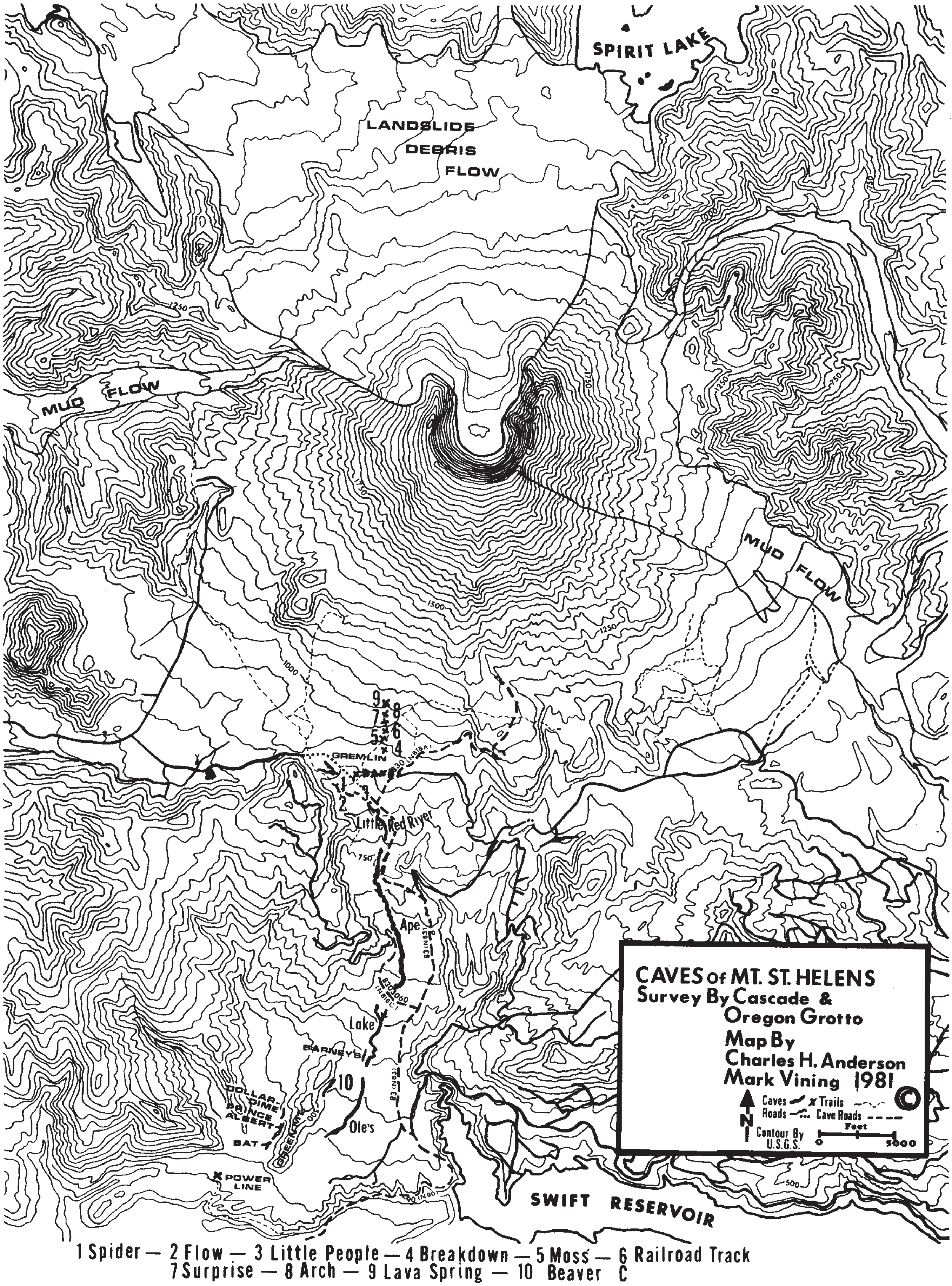

Figure 3. *The Mount St. Helens cave area is almost exactly 180 degrees away from the axis of the lateral blast of May 18, 1980. Map by U.S. Geological Survey.*

study area discussed here consists of the south lobe of the Cave Basalt Lava Flow, a Quaternary structure about 1,900 years old (Greeley and Hyde, 1972). It is the only known speleoliferous lava flow on Mount St. Helens and consists primarily of pahoehoe lava with a little aa. Its upper and lateral portions are largely covered by later lava, tephra, other aggradational deposits and by various types of forest and other plant cover, especially above road 81. The lava is best visualized in the caves. A total of about 10 km of caves has been mapped in this flow. The flow can be traced from an elevation of about 1,500 m to the north fork of the Lewis River, at an elevation of about 200 m. Contrary to some earlier opinions, its vent probably was at or near the pre-1980 summit. The flow contains several subunits which have not been adequately defined or described. These are especially prominent in the Utterstroms Caves area where all the caves except Breakdown Cave appear to be in a superficial subunit which may be significantly later than the bulk of the flow. In the mid-portion of the flow, Barneys Cave is in another subunit distinct from that containing the main throughway passage of nearby Lake Cave.

The section of Ape Cave downslope from its main entrance has two mudflow deposits about 450 years old. Each is at least 1.5 m thick. Other pre-1980 mudflow or flash flood deposits are present in Lake Cave and Little Red River Cave.

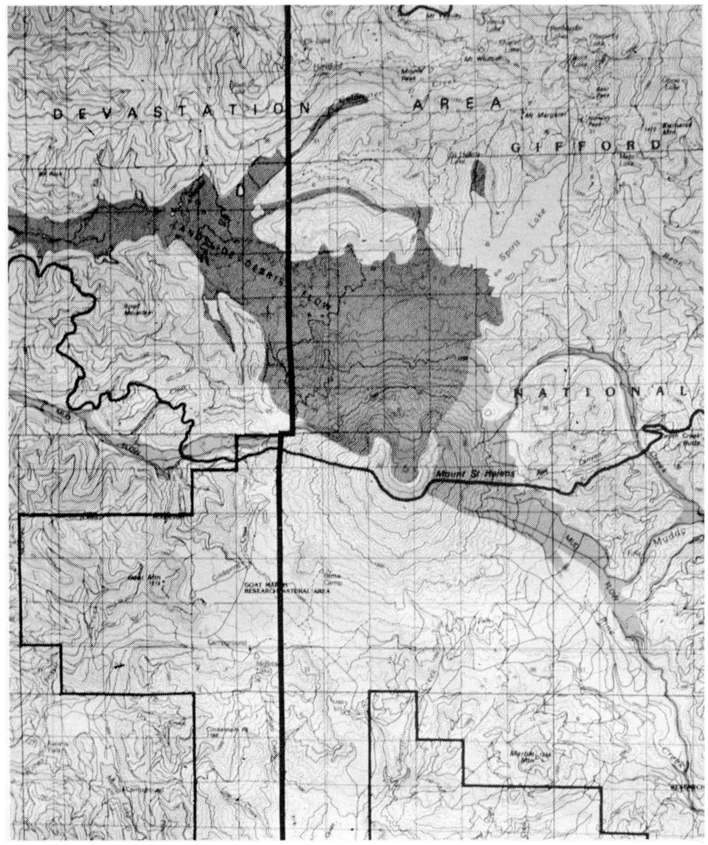

Figure 5. The Mount St. Helens cave area is almost exactly 180 degrees away from the axis of the lateral blast of May 18, 1980. Map by U. S. Geological Survey.

Airfalls of Tephra

Although the Western Speleological Survey research permit predated the famous May 18, 1980 eruption, we were not permitted to use it until June 22, 1980 and thus have no data on earlier post-eruption findings in this study area. Some aerial photographs taken in the first few minutes of the May 18, 1980 eruption suggests that collapsing columns of airborne tephra should have deposited airfall here. However, an interview with Mr. Ron Fields, a U.S. Forest Service employee who was at the northwestern corner of the cave area at the time of the eruption, indicates that the column collapse did not reach the ground here, and this is confirmed by photographs taken later on May 18, 1980 showing no tephra on the snowpack upslope from the cave area. Small amounts of airfall may have occurred here during the minor eruptions in March and April 1980, but if so, it was minimal and all traces thereof were obliterated by larger, later airfalls.

Figure 4. Other caves at Mount St. Helens are of national and international significance because of their size and features. This is a notable trench and tube-in-tube in Prince Albert Cave Photo by W.R. Halliday.

Presumably, on May 25 and June 12, 1980, however, the entire cave area underwent two episodes of airfall before our June 22 studies. Two accumulations of almost identical depth were found throughout the area. Oral communications from U.S. Geological Survey staff persons indicate that a third airfall occurred in the study area in September or October 1980, but use

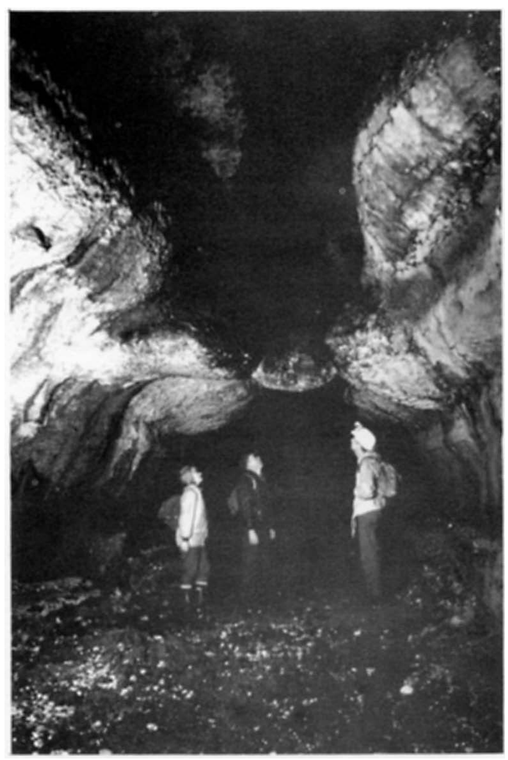

Figure 6. For several years after its initial mapping in 1958, Ape Cave was considered the world's longest lava tube cave. It is still the longest lava tube cave on either American continent. Photo by W.R. Halliday.

Figure 7. This is an unusually long lava "straw" stalactite in a Mount St. Helens Cave. Photo by W.R. Halliday.

Figure 8. Before this photo, at the main entrance of Ape Cave in June, 1980, two tephrafalls had deposited about 1 cm here. By November, 1980, heavy rains had washed almost all of it off the trees, which looked almost normal again. Photo by W.R.H.

Figure 9. Tephrafall at Moss Cave, about 6 km from the 1980 crater, was about twice as much as at the main entrance of Ape Cave. Photo by W.R. Halliday.

Figure 10. Eroded remnants of two pre-1980 mudflows in Ape Cave. Excavation has shown that the lower flow is at least 1.5 m thick. Photo by W.R. Halliday.

of our research permit was especially obstructed at that time and all evidence of this third airfall was obliterated by heavy rainfall in early November 1980.

Throughout the study area, the May and June 1980 airfalls were vertical. In the Utterstroms Caves area (about 5 km from the new crater), it measured up to 5.5 cm thick in compressed form. At the main entrance of the Ape Cave, its maximum thickness was 2.4 cm. Two distinct layers were present. At Ape Cave, the tephra had a powdery, fine-grained texture but washing revealed coarser elements. Closer to the crater, the tephra was increasingly coarse-textured and granular in appearance, but still contained a large percentage of powdery components. A few isolated fragments of light, airborne pumice were found in the cave area in June 1980. These were randomly distributed. The largest measured 3.8 x 2.5 x 2.5 cm; it was on the trail from the Ape Cave road to the main entrance of the cave. In March, 1982, showers of newly ejected pumice fragments were found atop the snow on and north of Road 81 north of Little Red River Cave. The largest of these was about twice as large as those found at Ape Cave in June 1980.

In comparison with mudflow events discussed later, only very small amounts of tephra entered caves as a result of gravity transport, with or without the effects of rainfall in the cave entrance. With the exception of some loss of moss and other low vegetation, the parts of the study area impacted only by airfall now look much as they did before the eruptions and provide a control area for parts of the Cave Basalt Lava Flow impacted by subsequent mudflows and other parts of the Mount St. Helens area as a whole.

Impact of Mudflows in the Cave Area

Post-eruption mudflows of two or three types caused large-scale physical changes above and below ground in some parts of the cave area. A clear sequence involving both post-eruption aggradation and down-slope delivery was observed, both above and below ground, related to:

1. the nature of the tephra,
2. the local surface and subsurface topography, and
3. surface and subsurface runoff.

Endogenous Mudflows

Except under unusual circumstances, the first aggradation in the study area was separation of a light tan mud from the remainder of the tephra. Its consistency was clay-like. Some clung to vegetation for many months, despite winter storms.

Yet, most of it separated quickly from larger tephra particles with light rain, long before seasonal rains seemingly washed the area clean in early November 1980. It hydrated and dehydrated quickly, and flowed and halted with seemingly minimal changes in hydration. By June 22, 1980, after light summer rains, it had accumulated locally to depths of many cm in the center of the study area. In the shallow sink of Hopeless Cave, it formed a quicksand which half-filled the low entrance. Two months later, after additional light summer rains, some of these local accumulations were several times as thick as in June. Locally, some had coalesced to form mudflow tongues. Some of these tongues had flowed into pseudokarstic swallets smaller than the entrance of Hopeless Cave. Although the color still was light tan, the mud was siltier and a small amount of gravel and pumice had begun to appear on its surface. By this time, the entire entrance sink of Hopeless Cave had been filled, with only a small swallet revealing its site. Subsequently, this entire area was buried by an accumulation of more than two meters of mixed streamwash, resembling the detritus of a desert wash. This location is about 150 meters up-slope from the main entrance of Ape Cave and the Hopeless Cave mudflow extended diagonally across the course of the cave. As of mid-1982, small new accumulations of this tan endogenous mud still can be observed after each rainfall in the general area of Ape Cave, especially at the downhill ends of mudflow tongues where the extremely fine-grained particles seem to separate disproportionately with low velocity waterflow.

Figure 11. Local runoff leading into Hopeless Cave after local aggradation in August, 1980. Photo by J. Nieland.

In limited underground reconnaissance in June 1980, we found no aggradation of 1980 tephra. In August 1980, we found thin deposits of tan 1980 mud in parts of Ape Cave. We were allowed to visit at the time, both upslope and downslope from the main entrance. It was entering through small local spatter points and through paratubal orifices unrelated to any discernable surface feature. Subsequently, reworking caused the tan mud to disappear in the part of Ape Cave downslope from the main entrance. Beneath the Hopeless Cave mudflow, this tan mud remains, up to eight cm thick. Present drip in this part of the cave, however, no longer contains mud. Therefore, it appears that the tan clay-like particles form a layer impervious to larger particles which has sealed minute orifices originally permitting its passage.

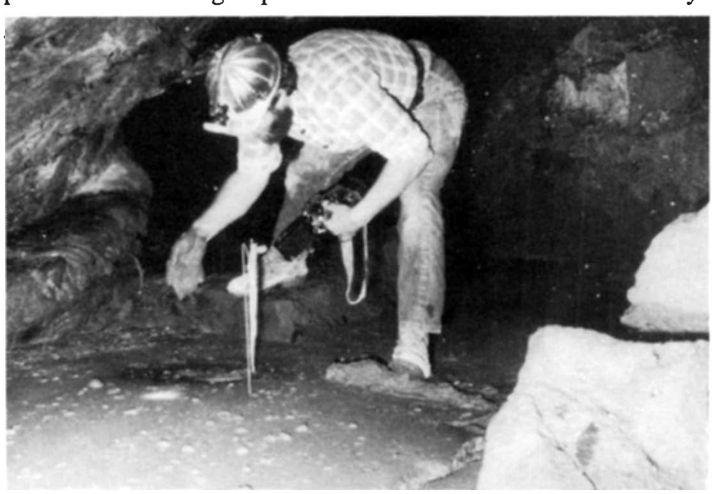

Figure 12. Tan mud rivulet in Ape Cave, August, 1980. Reworking soon destroyed all trace of this phase in this part of the cave. Photo by W.R. Halliday.

Exogenous and/or Mixed Mudflows

On June 22, 1980, we found another form of post-eruption aggradation in a small area east and south of the Utterstroms Caves, near the north end of the study area. This locality is about 5 km south of the new crater. Some local endogenous tan-colored mudflows were present here also, but in addition, the light summer rains had deepened one small gully arising high on the volcanic cone and a small amount of exogenous material had accumulated at various points along its course and spillover points. Also, we found unexpected headward erosion in a gully which had destroyed half the width of the Breakdown Cave access road, with obvious downslope transport of eroded material. Along the edges of this gully, large perched boulders indicated at least one recent period of torrential flow seemingly disproportionate to the light rains of the season.

About 1/2 km farther downslope, changes were more dramatic. Considerable pre-1980 streamwash had been redistributed from the bed and walls of the gully into and through an old "borrow pit" located in a clearcut. The upslope walls of the borrow pit had undergone marked headward erosion, exposing stumps and other features deeply buried by pre-1900 mudflows. These mixed materials contributed to a

Figure 13. Site of Hopeless Cave after Hopeless Cave Mudflow of about November 1, 1980. This view is looking past the site of the cave entrance to the road; formerly there was a bank about 1.5 m high at the edge of the road. Photo by W. R. Halliday.

new downslope aggradational plain composed variously of tan clay-like tephra, silty tan tephra and grey-brown tephra adulterated with pre-1980 materials, largely sorted by particle size. In the main axis of a braided downslope delivery system, streamwash had slightly gullied and aggraded a width of several hundred meters of Road 81 (then N818). The plain extended a few dozen meters downslope on the lava flow, from Road 81, close to several important caves. We named this complex the Road N818 Mudflow (later changed to Road 81 Mudflow when the enumeration of the road changed).

On August 24, 1980, we found one major gully in the Utterstroms Caves area temporarily lined with what appeared to be welded tuff, resulting from an exogenous mudflow associated with the August 7, 1980 (or July 22, 1980) eruption. A small tongue of this material extended as far south as Road 81. This soon disappeared as a result of reworking, however.

During the next six months, these gullies underwent rapid, extensive erosion, with repeated reworking and downslope enlargement of the Road 81 Mudflow. All traces of the "borrow pit" were destroyed by January 1981, and by November 1980, Road 81 was so deeply gullied as to constitute a geological exhibit rather than a road. This process is continuing, with broad sections of dying forest now standing in what looks much like a desert alluvial fan. Debarking of trees, and wedging of large boulders between trees several meters above gully floors, demonstrates the effect of heavy seasonal rainstorms.

A little low-load floodwater has spilled into Little Red River Cave, located close to the largest gully associated with the downhill extension of this mudflow and the site of at least one major pre-1980 subterranean mudflow. Another tongue of this mudflow, however, has deposited several cm of mixed streamwash in the main passage of Little Peoples Cave. A small subterranean tongue of the Road 81 Mudflow also resurged about 30 m north of Flow Cave and has deposited a small quantity of fairly fine-grained material in the entrance section of the cave.

Figure 14. Photo taken around 1965 of the road materials "borrow pit" on Road 81. After tephrafalls of mid-1980, headward erosion of this borrow pit resulted in extensive aggradation downslope and contributed to Hopeless Cave Mudflow. W.R.H. photo.

Different tongues of the Road 81 Mudflow are not simultaneous in advance and enlargement. The westernmost tongue was comparatively slow to advance. It did not reach the road until the summer of 1981. However, in approximately February 1981, it began to spill laterally into the lower entrance of Sand Cave. By October 1981, that entire pit entrance had been filled and a small tongue of mud also had entered the upper entrance. Only about 5% of the original volume of this cave is unfilled at present.

Figure 15. Road 81 just below the borrow pit in August, 1980. Subsequently, this area became so deeply gullied that it was difficult to see that a road had ever existed here. Photo by W.R. Halliday.

At the northwestern corner of the study area, the easternmost tongue of the Kalama Springs Mudflow (which we termed the Gremlin Cave Mudflow) entered the cave area at an undetermined time prior to August 22, 1980. At that time, we found it to be a largely silty mudflow just beginning to spill laterally into the lower entrance of Gremlin Cave after passing diagonally across most of its length. At this time, the mudflow was being enlarged by glacial meltwater carrying a heavy sediment load. It was aggrading Road 81, which it crossed at a 90° angle, thence following logging roads downslope as it spread out in the Gremlin Cave clearcut. Some of this meltwater also was running along a drainage ditch which then existed along the north edge of Road 81.

Subsequently, it became apparent that Gremlin Cave already had become part of a significant underground downslope delivery system. It continues to serve as an active intermittent

Figure 16. Figure 16. Possible welded tuff lining a shallow gully near the Utterstroms Caves group (August 1980). Photo by W.R. Halliday.

conduit for floodwaters and meltwater which intermittently carry heavy sediment, with sequential erosion and deposition of sandy material and vegetable debris along the spelean streamcourse which begins near the lower entrance. Headward erosion of the aforementioned trench along Road 81, with redirection of the main downslope delivery axis to the southeast, however, had reduced the burden of the stream in this cave. At present, erosion of subterranean post-1980 deposits is proceeding near this entrance, with continuing deposition primarily in the rarely-visited lower end of the cave.

Figure 17. Same location [as Figure 14] in January, 1981, after seasonal rains caused severe gullying. This process has continued to enlarge this and other nearby gullies. Photo by W. R. Halliday.

Figure 18. Aggradational plain and gullies downslope from Road 81, in the area of the Road 81 Mudflow. Photo by W.R. Halliday.

Figure 19. Lower (pit) entrance of Sand Cave in May, 1981, when a western lobe of the Road 81 Mudflow recently had begun to invade this entrance. Within a few months this entrance was too deeply buried for its site to be found. Photo by W.R.H.

On the surface here, some headward feeders of the flow still remain despite the redirection of most of the aggradation southeastward, down the remains of Road 81. These have enlarged and lengthened the western lobe of this mudflow. There has been some increasingly coarse aggradation, and some rechannelization of the eastern lobe into the cave, although much more slowly and on a much smaller scale than originally feared.

In January 1981, we found the sites of two resurgences of silty mud about 100 meters downslope from the farthest point of advance of this mudflow. They were in line between Gremlin Cave and Spider Cave, which is the next cave downslope. Their sources could have been any of several small, closed depressions invaded by tan, silty tongues of this mudflow, as well as Gremlin Cave itself.

The various exogenous and mixed mudflow tongues and post-eruptive gullies coalesced in a confluent zone west of Little Red River Cave and the upper part of Ape Cave. Thence, intermittent flow of high and low-load floodwaters has followed an old intermittent stream channel along the west edge of the lava flow to a point about 150 m upslope from the main entrance of Ape Cave. At this point, the stream course was blocked around 1960 by construction of a length of U.S. Forest Service road along the bed of the stream channel. This obstruction of the natural drainage appears to have been at least partially responsible for the diversion of floodwaters which in November 1980, caused the burial of Hopeless Cave. Subsequently, this was aggravated by the construction of a dam about 1/4 mile long here, consisting of bulldozed mudflow and quarry run rock, designed to keep the road open above Ape Cave. More than 1.5 m of mudflow debris has accumulated behind this dam to date, and it may already have been overtopped by low-load floodwaters. The result has been

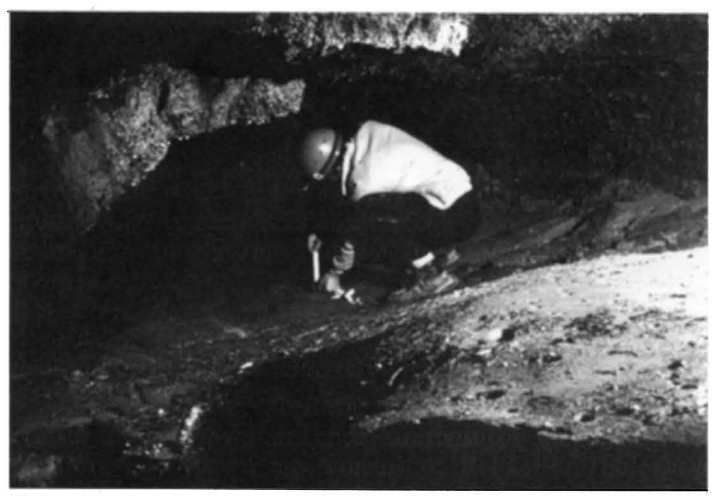

Figure 20. Another tongue of the Road 81 Mudflow invaded the upper entrance to Sand Cave by October, 1981. Formerly this was walking passage. Photo by C. A. Anderson, Jr.

Figure 21. *The Gremlin Cave Mudflow in August, 1980. The upper entrance of the cave is near the left edge of the photo; the lower entrance is just out of the photo at the right lower corner. Photo by J. Nieland.*

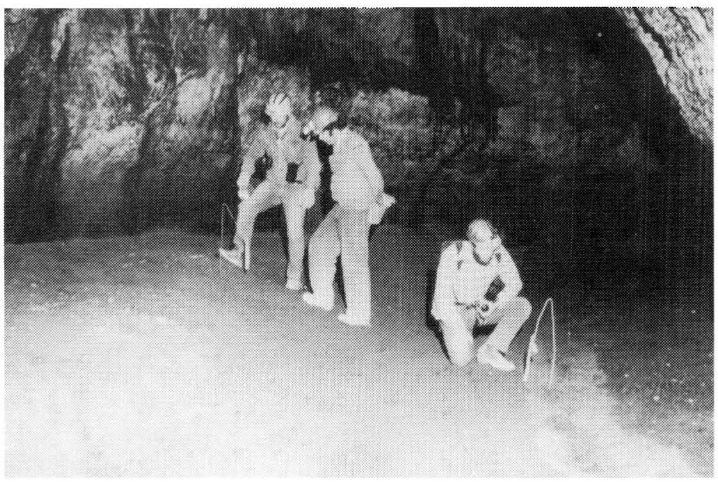

Figure 22. *Initially, the reworked tephra passing through Gremlin Cave was watery and fine-grained. Photo by W.R. Halliday.*

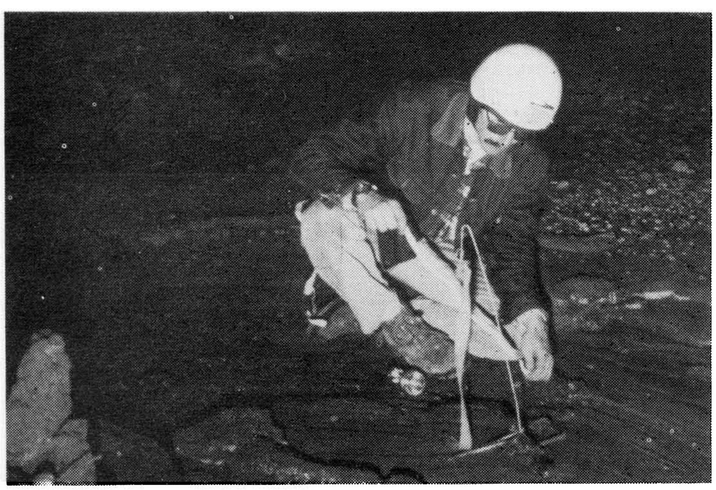

Figure 23. *Subsequently reworked material passing through Gremlin Cave became grainier and packed firmly. Organic debris on the station marker indicates recent high-velocity flow. Photo by W.R. Halliday.*

Figure 24. *For about one year, reworked tephra in Ape Cave could be distinguished from pre-1980 materials by its lesser consolidation. Photo by W.R. Halliday.*

Figure 25. *This mudflow resurgence upslope from Flow Cave is at the apex of a barely perceptible lava dome. Photo by W.R. Halliday.*

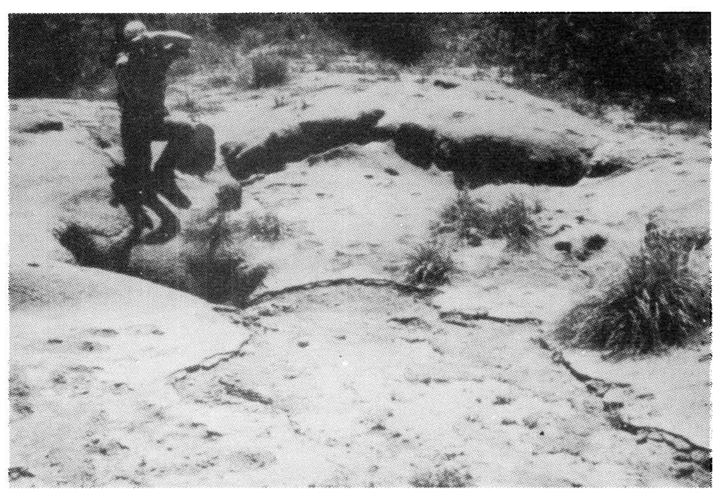

Figure 26. *A small amount of mud from this resurgence entered Flow Cave. Photo by W.R. Halliday.*

production of an alluvial plain at, and around the site of Hopeless Cave, reworked with each significant rain. Downslope, where the slope is steeper, braided tongues of this Hopeless Cave Mudflow extended southward, hundreds of meters past the main entrance of Ape Cave. Farther downslope, where the gradient was less, their coalesced bulk formed a small mudflat along the north side of the Ape Cave Road near the Lava Cast Picnic Area. Still farther south, where the gradient again is steeper, additional narrow tongues of similar material have been carried downslope in narrow gullies on both sides of the flow near Lake Cave. Lake Cave itself, the lava tree casts, and the downslope part of the lava flow apparently have not been impacted by this process.

To date, Ape Cave appears much as it did before the eruptions began. Only small quantities of low-load floodwaters have entered its main entrance, and their most significant effect was the destruction of the tan mud tongue seen in August 1980. Some 1980-'81 grey inwash can be distinguished from pre-1980 aggradation by its lesser degree of consolidation, and small quantities of sand have accumulated in the lower terminal crawlway. If the two-meter dam close to the main entrance should be breached by overtopping, with subsequent headward erosion in the mudflow debris accumulated behind the dam, however, invasion of Ape Cave by a mudflow tongue comparable to those of about 450 years B.P. may occur with little or no warning.

REFERENCES

Greeley, Ronald & Jack Hyde. 1972. Lava tubes of the Cave Basalt, Mount St. Helens, Washington. *Geological Society of America Bulletin* 83:2397-2418.

Halliday, W. R. 1962. *Features and significance of the Mount St. Helens cave area, Washington.* Washington Speleological Survey Bulletin 2 (Western Speleological Survey ser. no. 22), 6 pp.

Halliday, W. R. 1981. Mount St. Helens: The caves, the eruption, and the bureaucracy. *National Speleological Society News* 39:3-6.

Martel, E. A., ed. 1900. Spencer's Cave, Etats-Unis. *Spelunca: Bull. de la Soc. de Speleol.*, Tome 6(21-22):55.

Pryde, P. R. 1968. Mount St. Helens: A possible national monument. *National Parks Magazine*, May.

U. S. House of Representatives. 1982. Mount St. Helens National Volcanic Area. Serial No. 97-111, pp. 190-92.

U. S. Senate. 1982. Mount St. Helens National Volcanic Area Act of 1982. Publication No. 97-93, p. 235.