Grand Canyon Nature Notes, in press.

THE 1995 DEBRIS FLOW AT LAVA FALLS RAPID

Robert H. Webb and Theodore S. Melis
U.S. Geological Survey
1675 W. Anklam Road
Tucson, AZ 85745

Lava Falls Rapid is, at all water levels, the most challenging rapid in Grand Canyon (Nash, 1989). Its severity changed markedly in the early morning hours of March 6, 1995, when a debris flow from Prospect Creek constricted the Colorado River by approximately 50 percent. For Prospect Creek, the debris flow is the first since 1966 and the largest debris flow since 1955. The changes in Lava Falls Rapid are the most significant in Grand Canyon since the 1966 debris flow in Crystal Creek.

Debris flows are a type of flash flood that commonly occurs in steep terrain worldwide. They are slurries of sediment and water that typically contain more than 80 percent solids. The sediment ranges in size from clay to boulders; one boulder deposited in the Colorado River in 1990 weighs an estimated 290 tons. Although many debris flows result from human disturbance, debris flows in Grand Canyon National Park are totally unrelated to human activities. Instead, debris flows in Grand Canyon require intense rainfall, typically in excess of 1 inch per hour, and a slope failure in bedrock or unconsolidated colluvium at the base of cliffs. The resulting slurry typically flows 1 to 4 miles to the Colorado River.

The 1995 debris flow in Prospect Creek was witnessed by our research trip, which was sponsored by the Glen Canyon Environmental Studies (GCES) Program. Ironically, the purpose of our trip was to monitor past debris flows in Grand Canyon. We arrived at Lava Falls during the morning of March 4, camped about a quarter mile above the rapid, and immediately began repeat photography of historic photographs of the rapid, as we had done on many other research trips. This fortunate timing allowed us to thoroughly document conditions before the debris flow.

Although it had been cloudy with sporadic rain for nearly a week, March 4 was clear by

noon. Rainfall began at midnight March 5. Light rainfall continued steadily the following day, but we continued to match photographs and collect data on the rapid and the source areas of previous debris flows. The storm culminated in steady hard rainfall that began about 6 PM and continued until after midnight. No thunder was heard during the storm, and no estimates were made of the total rainfall.

At midnight, March 6, several gusts of wind blew down the kitchen tarps and turned over tables in our camp. Several trip members rose to stabilize the kitchen gear. After returning to bed, at approximately 12:30 AM, at least three members of the trip were startled by a roaring sound that came from the direction of Lava Falls Rapid. The exact time of the beginning of the sound is unknown but probably was between 1:00 and 1:30 AM. Part of the noise was identified as distinct rockfalls. Most of those that heard the roaring sound, including boatman Bob Grusy, were concerned that the river was rising with storm runoff and that boats or the camp would be threatened. Bob Webb remembers that the noise lasted 3-5 minutes and then subsided, but others thought the sound lasted much longer.

At about 2:30 AM, Grusy got up to find rising water and put extra lines on his boat. At about 4:00 AM, the rainfall had stopped, and Mimi Murov rose to take down the wash table that was threatened by the rising Colorado River. Murov thought it strange that the eddy at camp was pooled up and calm; she thought at the time that the high water was not from a Colorado River flood but instead resulted from an increased constriction downstream.

We all got up at 6:00 AM on March 6 to clear skies and a river that was 3 to 4 feet higher than the previous night. The Colorado River, which had a discharge of about 18,000 cubic feet per second, appeared ponded with little movement. After cleaning up the wind-strewn equipment in the kitchen area, we hiked to the left scout of Lava Falls to view what we thought would be high water flowing through the rapid. Instead, at 7:00 AM, we saw the new debris fan and recessional flood waters in Prospect Creek.

The debris flow began when runoff poured over a 1,000-foot cliff at the head of Prospect

Canyon. The water hit unconsolidated colluvium in the channel and its banks, and the added sediment formed a debris flow. When we first saw it, the waterfall was still spewing dark brown water into the upper end of Prospect Canyon at about 500-1,000 cubic feet per second. The waterfall, which had two long, vertical drops, sent a fine brown mist into the canyon. Flow in the creek was a dark chocolate brown, and boulders and cobbles could be distinctly heard rolling along the bed. The creek channel was too high to cross until about 3:00 PM, and flow in Prospect Creek stopped after dark on March 6. Storm runoff lasted 18-20 hours.

When we first saw it, the new debris fan extended into the river to about the left edge of the Ledge Hole, which is in the center of the rapid. The new fan extended about 100-150 feet into the river over a distance of 600 feet. The fan sloped continuously into the river with no sign of erosion on its edge. We immediately began photographic monitoring of the debris fan from the camera stations of previously matched views. Recessional floodwaters prevented access to the new debris fan. As the morning progressed, the edge of the debris flow was cut away by about 20-24 feet, leaving an 8-foot high cutbank on the left side of the rapid. Photographers on the left side of the rapid saw large sections of the new fan fall into the rapid. Recessional flow in Prospect Creek cut two channels through the debris fan, further reducing its size. The floodwater entering on the left side contributed to the failures.

The rapid was markedly different on the morning of March 6. The entry water was extremely fast. Some well-known hydraulic features, such as the Ledge Hole and the V Waves, were still present but greatly increased in size. The right lateral of the V waves became much stronger than the left wave. The Ledge Hole had a different shape, a sharper drop, and a stronger hydraulic than before. The Slot Run immediately to the right of the Ledge Hole was not apparent. Marker rocks, such as the Domer Rock (also known as Big Bertha) and the Meteor Rock, and their identifying waves and holes were not visible. The Big Wave, which used to form between the V Waves and the Black Rock, initially was very large but disappeared by the end of the day. A large, continuously breaking wave formed off of the Black Rock, and large whirlpools formed

to the right of and behind the Black Rock. Boulders were heard rolling along the bottom above the sound of the rapid.

Kenton Grua and Grusey both thought that initially the rapid was unrunnable. The waves on the right side of the rapid were huge, and it appeared likely that a motorized raft would be deposited on the Black Rock. Floodwaters entering on the left eliminated any possibility of running left of the Ledge Hole, which had a large breaking wave. Because there was no doubt that we were staying to study the debris flow, we will never know whether the rapid could have been run safely or not.

Downstream, the former eddies on river left and right were replaced by fast-moving water. A secondary rapid formed at the Warm Springs, but its waves subsided to riffle size as the day progressed. We interpreted the secondary riffle as water flowing around and over a new island where the pool used to be; the size of the riffle probably changed as a gravel/cobble bar migrated downstream into Lower Lava Rapid. By the afternoon on March 6, a run developed just to the left of the Ledge Hole.

On March 7, we had full access to both sides of the rapid and Prospect Canyon. We had a peak of 16,300 cubic feet per second in the rapid, but the rapid looked like a larger discharge was flowing through it. The debris fan did not change during the day. Most of the familiar features of the rapid, such as the Slot Run and the marker rocks, reappeared. The Ledge Hole remained slightly different and stronger than before. The breaking wave off the Black Rock was still present, and the secondary riffle remained small. The left run continued to develop and remained in a condition judged runable. The rapid appeared much more energized than before; the former right run appeared more than likely to flip oar boats, and the wave off the Black Rock was strong enough to potentially flip motor rigs.

On March 8 and 9, normal fluctuating flows were observed in the rapid. We still could not determine the discharge from the stage in the vicinity of the rapid. The entire rapid had a much higher velocity. Both Grua and Grusy felt that the right side appeared as if the discharge

were 6,000 cubic feet per second higher than it actually was. The entry to the right run is much faster, and the right side of the V Waves is much larger. The Big Wave only appears at discharges less than 10,000 cubic feet per second, but the continuously breaking wave off the Black Rock persists at all water levels we have seen.

We ran the rapid on 11,000 cubic feet per second on March 9. Grusy put his 37-foot motorboat through the right run; the rapid was faster but the run was easier because the Big Wave no longer exists. Grua ran the left run easily in a 22-foot motor snout, although that meant passing close to the Ledge Hole, running a large, haystack wave, and missing the Domer Rock. The speed of the water entering the left run was measured to be 15 feet per second. Both boats came close to the Black Rock but easily missed it.

The debris-flow project had previously identified Lava Falls Rapid as the most unstable in Grand Canyon. Because of the previously collected information, the new debris flow was easily interpreted in terms of size and recurrence interval. The most recent debris flow at Lava Falls were in 1963 and 1966; the 1995 debris fan exceeded the depositional area of these flows, and the 1995 debris flow eroded all the terraces deposited in 1963 and 1966. The 1955 debris flow was larger; the 1995 debris flow did not exceed the stage reached in 1955 and created a smaller constriction. Therefore, the 1995 debris flow in Prospect Creek is the largest debris flow in 40 years and the first in 29 years.

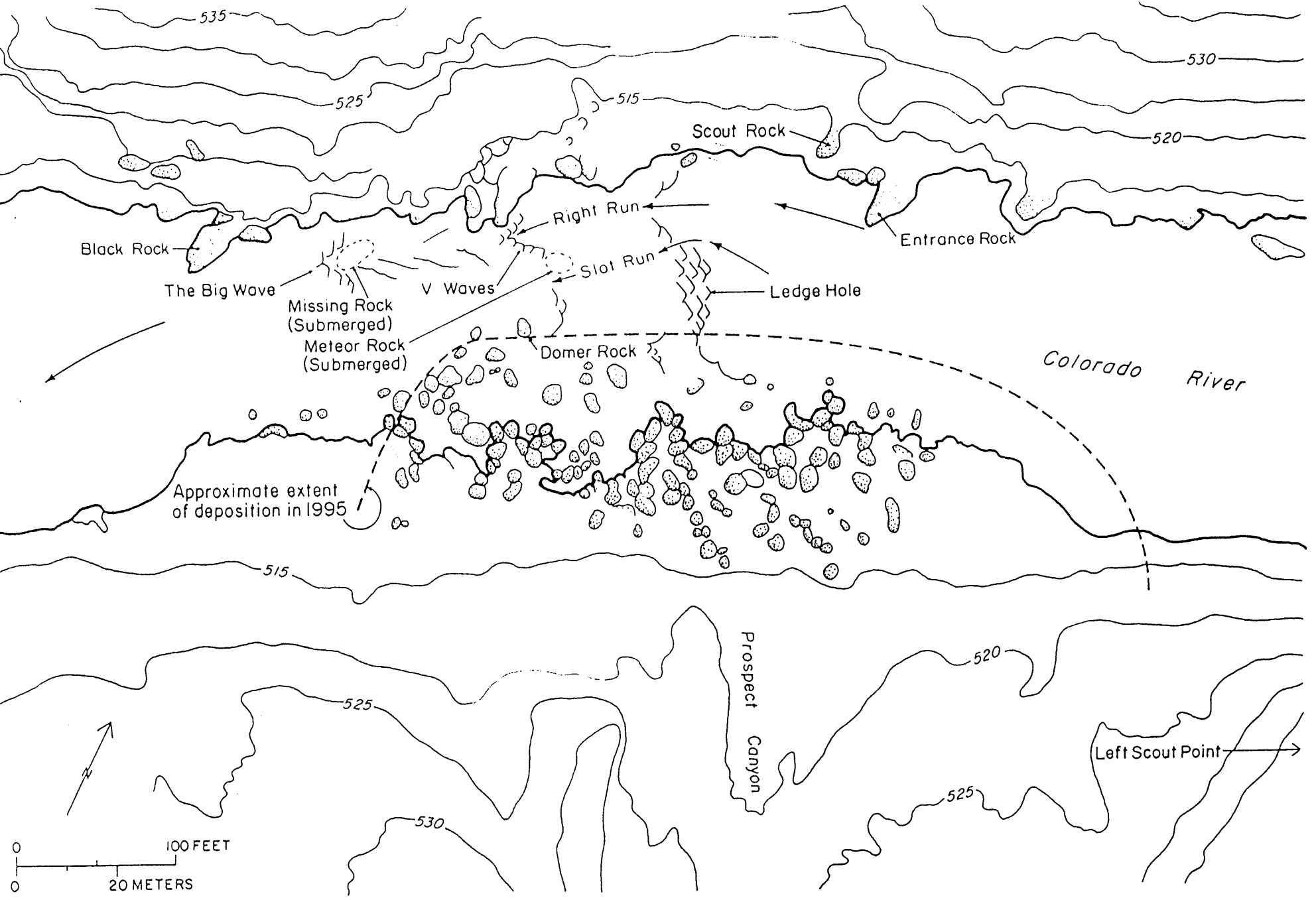
The 1995 debris flow in Prospect Creek set several benchmarks in Grand Canyon history. The storm that spawned it was only the second winter storm since 1872 that is known to have created a debris flow (after December 1966). The debris flow is the second largest in Grand Canyon since closure of Glen Canyon Dam (after the Crystal Creek debris flow of 1966). Changes to Lava Falls Rapid are less than changes to Crystal Rapid in 1966 but are comparable with other recent debris flows, such as House Rock Rapid in 1966-1971 and Specter, 24-Mile, and Bedrock Rapids in 1989. This debris flow reminds us that geomorphic processes are alive and well in the Canyon.

SELECTED REFERENCES

Cooley, M.E., Aldridge, B .N., and Euler, R.C., 1977, Effects of the catastrophic flood of December 1966, North Rim area, eastern Grand Canyon, Arizona: U.S. Geological Survey Professional Paper 980, 43 p.

Nash, R.F., 1989, The big drops, ten legendary rapids of the American west: Boulder, Colorado, Johnson Books, 216 p.

Webb, R.H., Pringle, P.T., and Rink, G.R., 1989, Debris flows from tributaries of the Colorado River, Grand Canyon National Park, Arizona: U.S. Geological Survey Professional Paper 1492, 39 p.


535
525
515
530
520
Scout Rock
Right Run
Entrance Rock
Black Rock
Slot Run
Ledge Hole
The Big Wave
Missing Rock
(Submerged)
V Waves
Meteor Rock
(Submerged)
Domer Rock
Colorado River
Approximate extent
of deposition in 1995
515
Prospect Canyon
520
525
Left Scout Point
525
530
0
100 FEET
0
20 METERS