Anatomy of a Rockslide

Jim Snyder

Rockslides have not occurred very often in the last century on the foot trail from Happy Isles to the Vernal Fall bridge. Slides have occurred more frequently on the Mist Trail, the horse trail, and especially on what is now the foot trail from Vernal to Nevada Fall. Only two slides have been recorded as falling on the trail below the Vernal Fall bridge. An earthquake on May 25, 1980, shook a large block from the ridge above Sierra Point, destroying the trail to that point before it landed on the Vernal Fall trail. The second slide or series of slides occurred this past spring.

The trail itself tells the area's recent rockslide history. Much of the trail is hung on steep cliffs lacking the talus slopes of marked rockfall occurring on the opposite side of the canyon. The stretch of trail by the spring above Happy Isles bridges marks one fairly large talus slope showing rockfall from Grizzly Peak. The other talus along the trail is several hundred yards below the Vernal Fall bridge.

Look at the size of the trees growing along the Vernal Fall trail. Look at the lichen on the rock. Except for the new slides, there is little bright, freshly broken rock. In the human rather than geologic sense of time, rockslides along this trail are rare.

Rarity was overcome in a rush this past spring when three slides occurred at the same location within 30 days. Rock structure laid the groundwork for the slides. If you stand safely out of the way and look at the points of release from the Vernal Fall trail, you can study the rock and see a pattern of fracturing resembling the illustrated cross section.

The predominant rock is what geologists call Half Dome Granodiorite. It is certainly massive, though the mass at the point of the slide is underlain by strata of thin layers of chemically more diverse rock shown across the upper center of photograph #1 and the lower center of photograph #3. The slope of the rock face and of the long slip joint lying underneath the failed blocks is about 70° dipping sharply south toward both river and trail. Another plane of fracturing shows in the remaining roof of the slide in photograph #2 dipping gradually north away from the river. And there is a series of vertical joints as well. This complex system of fractures, greatly oversimplified in the illustration, means that the rock has little to hold it in the long sense of geologic time. Other forces and gravity work slowly to chip away at the mass, converting it to talus along the Merced River at this point.

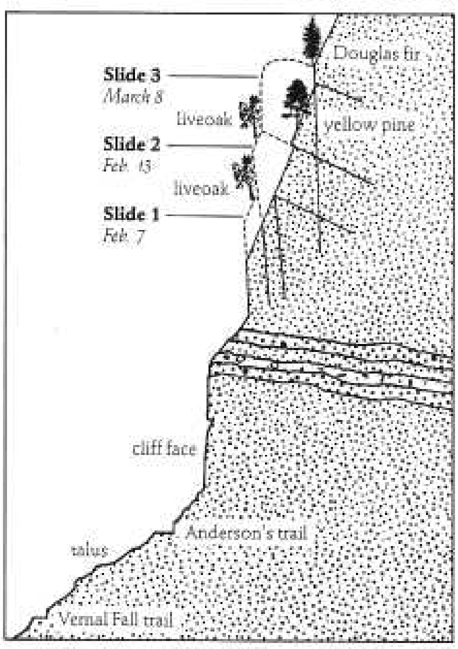
While the action of the slide is set in the rock structure itself, several other agents work on that structure to make parts of it fail and fall. One agent is vegetation and another is water. Earthquakes can play a role in widening fractures, but they have rarely been the direct, immediate cause of Yosemite rockslides.

Masses of rock move along the great joints shown at every turn in the trail. The movement often leaves cracks. Water washes soil and debris into the cracks which many plants then pionee The canyon liveoak is particular fond of rocky places and thrives on the soil and water supplies provided by cracks in the granit mass. Pines and firs will also tak advantage of the cracks and can thrive if the sources of life are generous enough for them in such ordinarily inhospitable places.

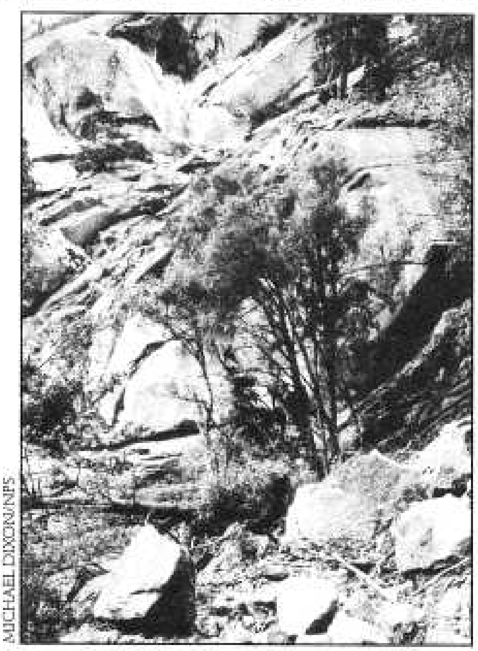
A tree sprouts in a crack and sends its roots down for nutrien and water. The roots work slow to expand some cracks and ofte travel hundreds of feet down in side the rock. Cracks trap soil, and trees generate more soil. Water flowing off the slick rock saturates the soil in the joints which act as deep wells for plan that otherwise would have little indeed to live on.

Liveoak roots are the toughes of all, forming thick mats in the cracks. The dark mass on the re- lease point shown in photograp

Rough cross-section of the slide area.



1. The release point of the Feb. 7 slide is in upper left center just above the thinly stratified rock crossing the picture. The dark splotch on the release point is a mat of liveoak roots left from a tree that came down in the slide. Liveoaks at the top of the release point were active agents in producing the second slide.



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2. The release point of the Feb. 13 slide shows the three major planes of cross-jointing. The fir at upper le and the small pine on the right con tributed to the third slide. Lighter streaks on the fresh rock are caliche deposits from water seepage.

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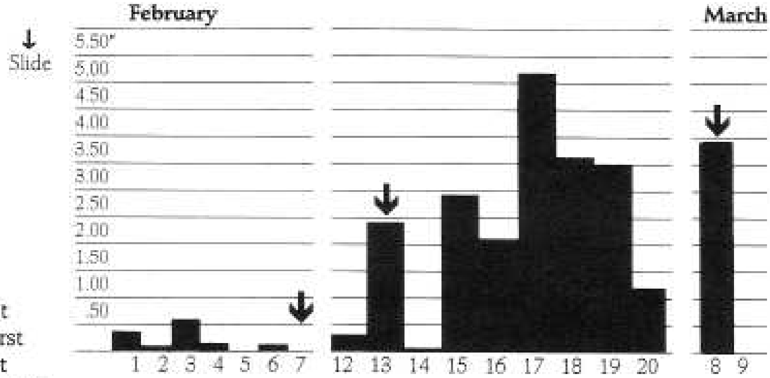

#1 is one of these liveoak root mats. Liveoaks initiated the first slide by loosening a block that was foundation for several blocks above it. The trees' search for sustenance, in other words, is their undoing, and their living is the source of their demise.

The second agent is water which can affect joints and cracks in several ways. Granites weather very slowly by water. Joints may be very fine at first, hardly even visible, yet water will slowly weather the chemical weakness there, dissolving elements of the rock slowly over time to open the joint.

Water also works as ice. Freezing and thawing expands cracks and slowly widens joints. When this process is compounded by deposited soil which acts as a great sponge, widening can be increased. Remember, however, that this process occurs in geologic rather than human time.

Once a crack is filled with roots and soil, water can act in other ways. Soil in the cracks can become so saturated that the weight of material in the cracks and pressures on any weak block are greatly increased. Larger amounts of water also sharply reduce the friction supplied by the debris in the joints, putting greater stress on remaining connections in the rock itself. Especially in situations with sharply dipping joints which leave few natural ledges for blocks to rely on, larger amounts of water in the joints grease the skids for weakening and failure. This is just what happened to cause the Vernal Fall trail slides.

Rainfall in Yosemite Valley during February and early March helps show how the slides occurred (see chart). There was not that much rain or freezing before the first slide. But the liveoaks growing over the poorly supported small block had loosened it enough that the light rain probably provided some of the push needed to break it loose. The first block fell at 1:20 p.m., Feb. 7.

That first slide removed much of the toe or foundation from the blocks above it. The piece that fell was thicker at top than bottom, a fragment formed by the intersection of the vertical with the south dipping joints shown in the illustration.

With foundation gone and water pouring through old weathered cracks up to a foot wide and filled with roots and soil, the second block of some 1,200 tons broke loose about 4 p.m., Feb. 13. The new roof clearly showed the structure of the remaining rock and the causes of the slide. Most of the joints had weathered, and there was little to hold the block in place. In fact the whole block had dropped about a foot and broke off just the remaining rear portion before falling. That remainder is the triangular piece at left center in photograph #2. This slide buried the trail in big blocks, tearing out many trees to make this once again a "new" and active, rather than old and stable, talus slope. For the first time in over a hundred years, the trail was hit by a major rockslide.

This second slide was followed by a period of heavy storms with widely fluctuating snowlines. That snow would fall in the Valley at one point, changing to rain to 8,000 feet within hours, meant increased water flow off the slickrock and additional stress along well-jointed rock.

Climbers from NPS Search and Rescue, Jerry Wieczorek and Chris Alger from the US Geological Survey, and I checked the remaining block on March 6. We saw slight movement there and, most important, some fine, fresh stress cracks along the top of the block. These, along with a very wide joint at the rear of the block and its position on a steeply dip-

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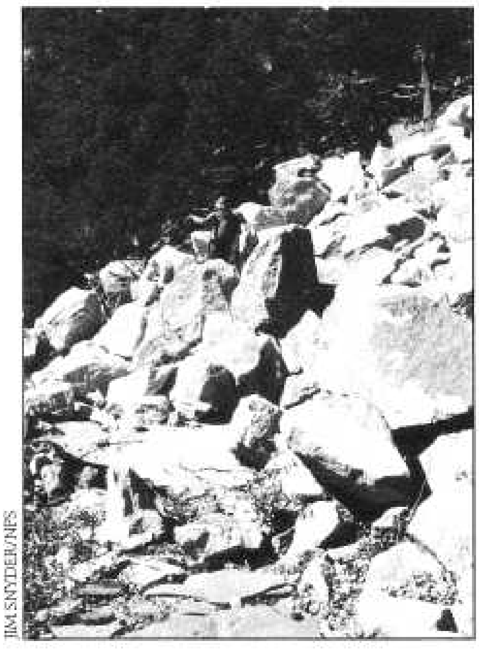
3. The release point of the March 8 slide is at upper center, capped by the remaining hundred ton block. The ragged edge especially at left center shows one of the broken connecting points. The bright rock surfaces dipping sharply toward the river show how gravity was favored.



JIM SNYDER/NPS

4. Rock was piled on the trail up to 12 feet deep after the third slide. In fact, there was no trail left.

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5. This block just east of the second release point shows a vertical fracture generated by the March 8 slide. Two smaller onionskin fractures work in from the edge of the rock at right. In the lower left corner are some of the roots from the small yellow pine. This block, already weakened, supports several others above it.

Rockslide

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ping plane, suggested where the break would occur. We determined to monitor the cracks. Only two days later during another heavy storm, the third slide occurred bringing down another 1,600 tons of rock and clearing away most of the precarious overhang. This last block had been held solely by its western connection, roughly eight feet square, not far from the stress cracks and the heavy rain reduced the friction enough that the connection could not hold; the block swung down, snapping its connection.

As it fell, the block slid and bounded along the steeply inclined plane, landing first on the small bench formed by more finely stratified rock. There the impact left a considerable crater and broke the block up further to increase its impact on the talus below. Impact also knocked out a smaller block below the thin strata, and that may provide now a new roof for future slide activity. Impact in the talus moved an additional 2,000 tons of rock downslope, forming a huge talus gully and burying the trail location up to 12 feet deep, shown in photograph #4.

Because it was next to the river, the trail could be easily cleared by blasting. Checking the new release point confirmed suspicions that the slide activity was not yet over. A hundred ton block perched at the top of the release point had moved slightly and showed some new cracks along its base. Roots behind remaining slabs suggested that remaining connections were often only at one end, leaving gravity the upper hand under the right conditions.

As the last slide fell, its falling put stress on surrounding rock. We could track that stress and see where it was likely to produce future slides. Photograph #5 shows a rock just left of the small liveoak on the right side of the release point shown in photograph #3. The rock cracked and moved about one quarter inch on March 8. Two smaller cracks show the work of that onionskin weathering pattern common to many rocks. This rock, however, is a large part of the support for blocks above it. When it falls, its failure will duplicate the situation of Feb. 7 by leaving a roof with several less supported blocks over it. Slowly, or maybe quickly, the slides will work up to the hundred ton block which will then crash to the talus below.

This slide sequence may also move the instability a little further east, opening new weak points along those sharply dipping joints. Among other things, this means that the rock structure is complex enough that no human effort can effectively stabilize the remainder. Taking one block down would only weaken other rock sections and create an endless and impossible maintenance task.

This situation posed a problem for the trail below and the thousands upon thousands of people who use it each year to see Vernal and Nevada falls. Once the rains were over and temperatures rose, danger of another slide decreased. Modification of the slides' release points was out of the question and the trail's great popularity eliminated closure as an unenforceable option.

Consultation with Service officials and the Department of Interior Solicitor led to a plan for the trail. Recognizing that "tort claims are the cost of doing business in a national park," the Park Service has to make "every reasonable effort"—"reasonable" is a key word—to tell visitors about potential hazards in the park. Knowing the rockslide potential, Service personnel also have to monitor the slide area. Normally trailhead signs warning of these hazards would be enough, but, because this trail is so heavily used, often by novice hikers, th Solicitor also recommended si at the slide area itself. These si specific to the hazard, state

Caution
Active Rock Slide Area
No Stopping Next 150 Yar

I walk through the slide are nearly day and watch people passing through it. Most pay li attention, but some become acutely aware of what the rou trail means. One gentleman fr England asked about the slide as he looked up at the marked fractures. After hearing a little about how it all happened, he exclaimed, "It's simply majest as many others scurried aroun us. He sensed for a moment th crash of breaking rock, the sm of grinding granite boulders, a the instant in which great falli weight made another forceful landscape change.

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Hydromantes

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habitats? Why are they the only genus of lungless salamanders in the old world? Lyell, whose revolutionary book, *Principles of Geology,* inspired Darwin and his theories of evolution, would have looked for geologic clues to these questions. However, he would probably be as baffled as modern day scientists who are using theories based on continental drift and glaciation to explain how Hydromantes ploddingly dispersed and mysteriously became separated. Using biochemical analysis, it has been estimated that European and Sierran Hydromantes have been separated 30 million years (distant cousins indeed!) This date does not fit well into the time frame of any of the dispersal/separation theories and so the mystery lives on.

It is thought because of certain primitive features that the limestone salamander is most closely linked to the ancient Hydromantes from which the others evolved. Deep in the past, Hydromantes might have been living from North America across Asia to Europe. When climatic conditions dramatically changed, only populations in suitable environments survived. Thus, relic populations adapted to changing conditions in their particular environment and now, presto—we have 6 unique species. Perhaps out there in other unlikely places, other mutated Hydromantes remain undiscovered.

On this planet where continually changing environments have wiped out 9/10 of all life forms, these flattened bug zappers have survived. Now their only current threats are changes created by "Lord Man" as John Muir, the Sequoia's savior, called us.

New Home

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automobile became popular, re sulting in the railroad's financia collapse in 1945. When the line was abandoned, a Mrs. Della Gress bought the Bagby station and set up housekeeping. Ther she lived until shortly before th waters of the upstream Exchequer Reservoir lapped at he doorstep. She sold out to the Merced Irrigation District.

Meanwhile, Chief Park Nat ralist Doug Hubbard had laid plans for an elaborate transpor tion museum at El Portal, plans which included the Bagby Station. Through the YNHA, the s tion was acquired in 1966 and moved to dry ground in El Port There it sat neglected, the plan for the museum having bogged down in money shortage problems. Despite its formerly forlo condition, it has been designat as an historic structure on the National Register. Its new utiliz tion as offices should benefit b the building and the Yosemite Association.