PRELIMINARY GEOLOGIC REPORT
NEAR MAMMOTH ELEMENTARY SCHOOL
EARTHQUAKES OF MAY 1980

[Editor's Note: The following information is abstracted from Pierre St.-Amand's preliminary notes of earthquake damage and geology near the Mammoth Elementary School. Pierre spent 4 days in his field examination. DJL]

Intensity of Shaking

The intensity of shaking at the Mammoth School was considerably more severe than elsewhere in the Mammoth area, except perhaps along the trace of the Hilton Creek Fault. The lack of suitable structures, people to interrogate, and similar amenities makes it hard to estimate the intensity of shaking along the Hilton Creek Fault; however, boulders were rocked out of their nests, numerous large boulders fell down hills, and some small slumps and landslides were initiated. The intensity at the school yard was more severe than in Mammoth Village, the airport, or parts of the fish hatchery.

Gravel was bounced off the roof of the schoolhouse. Books were thrown from bookcases, particularly on east and west walls. Furniture moved freely, some heavier objects being displaced several feet. Fluorescent light fixtures in the main hallways fell, almost without exception. Parts of fixtures fell in every room in the school. Air conditioning ducts were shaken from the ceiling and walls. Ducts on the south wall of the multipurpose room were projected into the room.

The multipurpose room exhibits 1/2 to 1 inch cracks in the floor that run the length of the room. The west walls, near the south end, were seriously distorted, plaster cracked, etc. Objects in storage rooms were flung to the floor. The multipurpose room was dropped about 2-1/2 inches with respect to the north wing, located contiguous to it. The small building situated near the extreme north end of the north wing was displaced at least 4 inches to the north with respect to the north wing. Every room in the school has one or more cracks in the floor.

Cracks were to be seen in the school grounds to the east of the north wing, in the earth and in the asphalt covering the walking areas. A hole into which water drains has developed in the school ground. A similar hole was covered over and filled up when the swings were last installed. The cracks in the ground run in a variety of directions, but the main trend is east-west.

Cracks are noted in all parts of the campus. Some were obviously there for some time, but many are new and have sharp edges. The asphalt covering the ground is broken with these cracks. To the west of the main building, the earth is intimately crazed, being broken into many small pieces and virtually pulverized in spots. Lurch cracks parallel to the bank are found near the edge of the meadow. The cracks in this area are predominately aligned east-west, but some can be found at all angles. One prominent line of cracks near the northwest end of the school yard is aligned north 70 east. This collection of cracks is in a zone about 2 or 3 feet wide. Individual members of the zone are left-stepping en echelon fissures, indicating that some right slip movement occurred on these. The cracks emitted water and mud during the earthquakes, and developed miniature mud volcanoes. This line of cracks is continuous with a line of springs along a fault scarp on the northern edge of the property.
The intensity of cracking noted in the field to the north and west of the main building is unusual except for locations near to a fault that has moved.

**Auxiliary buildings** located to the south of the school were jostled, but not as violently as were buildings on the north and east sides of the main building. A collection of small garages and repair facilities for buses was quite heavily shaken. One large bus, weighing at least 10 tons, bounded up and down on its springs so that the frame of the bus came into contact with the air brake cylinder, mounted on the axle, and broke it. The vertical oscillation of the bus body must have been in excess of 7 inches to have produced that effect. The buildings were deformed, tie rods stretched, screw heads pulled off the screws, etc. Some questionable welds failed. The floor in the bus garage is offset vertically about 1/2 inch. A **portable building** mounted on screw jacks moved to the east with respect to the foundations, the screw jacks being bent.

The intensity seemed highest in this locality. A low scarp separates this portion of the school grounds from the **fish hatchery** grounds. The shaking at the bottom of the scarp was equally intense. One house situated at the base of the scarp near the continuation of the line of springs was displaced, footings and all, with respect to the earth. The house is presently separated from the floor pads of the porches by several inches. Dirt has been pushed up around the south and east sides of the foundation, and a gap is visible around the foundations on the north and west sides. Clearly, the land moved west while the building stood still.

Similarly, a large **propane tank** situated at the foot of this scarp moved about a foot to the east with respect to its foundations. Once again, the foundations moved to the west and the tank stood still. This sort of displacement is usually caused by "fling" or the actual offset of a fault.

The shaking decreased in intensity to the east, until the first of the large evaporators is reached; between the two evaporators, it increased again. Numerous cracks in the ground, settlement of fill, and similar signs of hard shaking are visible there. To the east the shaking once again decreases.

**Intensity as Compared to the Earthquake Magnitude**

The intensity of the shaking in the schoolhouse and yard is out of proportion to the shaking to be expected from such a small earthquake, or earthquakes, as occurred. The only explanation is that some movement on faults beneath or adjacent to the property took place during one or more of the main earthquakes.

**Faulting in the Area**

The more prominent faults in the immediate area are shown in Figure 1. This is a map prepared from aerial photography. The major fault, and the one upon which the earthquakes are supposed to have occurred, is the Hilton Creek Fault. This fault is noticeable as a series of scarplets in alluvium between Tobacco Flat and McGee Creek. This series is discontinuous, marked by springs and small landslides. Where the Hilton Creek Fault crosses McGee Creek, it displaces the glacial moraine some 30 feet or more vertically, mountain side up. This fault, or what ought to be it, is last visible as it crosses Tobacco Flat. A second fault with multiple scarplets in alluvium is visible downhill from the Hilton Creek Fault. The course of this structure is not clear because of all the glacial, alluvial,
Figure 1. Fault map of Mammoth area, prepared from aerial photographs. Complete coverage was not available for the mountainous area.
and pyroclastic deposits on top of it. It appears to continue south-southeastward sub-parallel to Highway 395 and across the hills by Tom's Place. This fault has not been worked out with certainty as yet and will have to be the subject of a careful study in the future because of possible impact on construction.

The large moraine, to the south and east of Convict Creek, is cut by a fault that strikes in the general direction of the airport. This fault is extremely hard to see in the alluvium to the northwest of the moraine. It cannot be followed past Highway 395 with the photography available to me now. A subdued trace is visible along the extension of this line in the alluvium to the east of the airport runway; it is shown as a dashed line.

One fault passes across the southwest tip of Doe Ridge, a flow of a very viscous lava. This fault passes through a gravel pit to the north of the eastern end of the runway. It is clearly visible as a scarp that displaces the surface up to 10 feet. This fault moved during the earthquake. Cracks are to be found all along its length, some of them up to 2 or 3 inches wide. A line of cracks coinciding with this trace is easily followed across the recently disturbed surface of the gravel pit. Similarly, cracks abound in the vicinity of the road between the fish hatchery and Hot Creek Road. The minor branches of this fault to the west of the main trace also showed cracking.

On the other side of Hot Creek, the trace of the fault through the hot pool shows cracking as does the fault that passes through the old kaolin mine. Several large rocks rolled down the 8152 foot hill in Section 27. One of the rocks was the size of a small house.

To the northwest of the fish hatchery and school, on the far side of the meadow, is a linear valley that is clearly part of a fault zone. The faulting in the floor of the valley is obscured by loose, pumiceous alluvium; but on the west side of this valley is a prominent graben, indicated on the map, that clearly shows signs of having moved. Cracks up to 4 inches wide and several tens of feet long are located within the graben in dry ground near the meadow. Cracks are found along both sides of the graben as it goes up the hill, at least as far as the first col. To the north, the graben becomes part of a major fault system that contains several old fumaroles. The northeasternmost branch of this graben can be traced across the meadow; it forms the ridge just to the west of the school property.

The fault that cuts across the northwest corner of the school yard has already been mentioned. This fault underwent motion during the earthquake as evidenced by a line of open, en echelon cracks from which mud was extruded during the shaking. Several other faults occur near the school; one subparallel to the one just discussed passes to the south of the school and fish hatchery. This is joined by a short scarp to the one on the other side of the school yard.

The faults just discussed are part of a north to northwesterly trending set that dissect the rhyolitic hills to the north and west of the school. This set of faults is very probably a northward extension faulting farther to the south. It is true that the strike is somewhat different. This is not surprising in view of the fact that an enormous discontinuity must be present at the foot of the Sierra where it rises from the flats of Long Valley. The frontal fault of the Sierra, shown where it is indicated by Steven Lipshie (1972-74), must cut off all these faults, except for those to the east of the airport.
East side, Long Valley, north of Benton Cross Road. Irrigation ditches (behind people) filled with mud from below. Old ditch floor is covered with water plants. Note width of zone.

Power poles sank into mud across lake; guy wires slack. Mud extruded from ground around base of poles. Poles out of line all across valley. Note directions of insulators.

(Photos: Pierre St.-Amand)
Fault Discussion

It is customary to speak as if an earthquake had happened on a particular fault, as if that fault and no other had moved during the event. This is not the case. Usually, movement takes place over a considerable length of a particular fault and on a number of nearby faults. Almost every fault within a radius of 10 to 20 miles of a magnitude 6 earthquake will move a little. Moreover, it is clear that the faults just discussed did move because evidence was found for it.

Geology of the Mammoth School Site

The whole of this part of the valley lies within what is called the Long Valley Caldera. This is a giant explosion pit formed about 700,000 years ago and refilled with pyrotechnic ejecta from the explosion, with glacial debris, and with new lava flows and pumice deposits.

Intermingled with this melange are layers of clay and recent alluvium; the whole is thoroughly saturated with ground water. The school, as evidenced by the log of a well drilled to the west of the main building, is situated upon about 50 feet of lava, a few feet of sediments, another thin lava flow, with the whole resting upon pumice and gravel. Thin lava flows are not usually mechanically sound in that they are often broken and fractured. This particular lava is resting upon water-soaked sediments. The water level in the lava is about the level of that in the meadow because the lava serves as a confining bed for ground water descending from the mountains to the south and west. This higher hydraulic head is manifested as a series of springs along the north and easterly edges of the lava, where it is able to escape. These springs furnish part of the water for the fish hatchery. For at least 2 weeks after the earthquake, these springs were milky. Water from one spring about 10 feet into the valley and away from the scarp is at least 2 feet higher than the surroundings.

The presence of water-soaked sediments beneath the lava will exacerbate shaking from whatever source, particularly from nearby earthquakes. The sediments will also serve to distribute any changes in level over a greater width than would be the case if the school were on bedrock. Thus, it is hard to follow a fault scarp through the lava because the fracturing is distributed over so many branches of the fault, considering that all the fractures in the lava act as faults.

Not only will earthquakes be a problem in this sort of terrain, but the presence of the ground water that will change in hydraulic head with changing seasons and with drought and wet years will present a continuing problem of foundational stability, manifesting itself as a continued cracking of floor slabs and pavements, even without more earthquakes.

Discussion

The three magnitude 6+ shocks were not large earthquakes. Judging from the appearance of the scarps on the Hilton Creek Fault alone, it is likely that the area has been visited by earthquakes in excess of magnitude 7. It is quite likely that they will be so visited again. It is appropriate to ask if a magnitude 6+ earthquake did so much damage what would an earthquake of magnitude 7+ do?

This study is incomplete. With proper aerial photography, more detailed topographic maps, and seismologic information not yet available, a great deal more information
will be developed. High angle dawn and dusk aerial photography at appropriate scales would reveal additional faults not visible on the ground. Borings could reveal the displacement of lava flows and monitor hydraulic head. The observations and general conclusions are considered sound.

This series of earthquakes began in the fall of 1978. Judging from the way they have been behaving and the rapidity with which the aftershock train has died out, I feel that the excitement is by no means over. In the past is the key to the present and the future. One may expect larger earthquakes upon this fault complex in the future.

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West side of Arcularius Ranch north of Cashbough Ranch. Meadow dropped 5 to 6 feet. (Photo: Pierre St.-Amand)