

Sierra Resort Rattled By Earthquake Scare

By CHERYL CLARK
Staff Writer, The San Diego Union

MAMMOTH LAKES — When U.S. Geological Survey scientists last May issued a notice about a tongue of hot magma lurking beneath this volcano-prone community, many Mono County residents bubbled with outrage.

County politicians blasted the agency's red flag about potential volcanic hazard, lava, mudflows and floods, saying it was "precipitous and without precedence," causing "fear and concern" to residents and tourists.

In a July resolution, the Mono Board of Supervisors referred to the "alleged" volcano, whose spectacular eruption 700,000 years ago was 1,000 times more powerful than that of Mount St. Helens in May 1980. That cataclysm belched an estimated 140 cubic miles of rock and ash, carving out what is now Long Valley south of Mono Lake.

And the Chamber of Commerce president, urged by local businessmen who rely on millions of dollars of resort trade, pounded out an angry letter to a reporter who had quoted one of the USGS scientists saying he would have qualms about living in this high Sierra refuge near Yosemite National Park. Although the chamber president said he later apologized, his members still believe that would-be tourists are canceling plans to come to Mammoth, not just because of a general economic malaise but because of fear.

Although the community now feels the rumble and quiver of earthquakes weekly and sometimes daily some of them registering 4 and 5 on the Richter scale, a large share of its 5,000 permanent residents still speak with disbelief that activities deep within this scenic wonderland could ever disrupt or end their mountain existence.

They can't imagine an ejection of pyroclastic flows, hot glass and ash avalanches and vapor, or what that might do to the single main exit route out of the mountain-ringed town. A Mount St. Helens in Mammoth is just too incomprehensible for one of the country's largest ski areas.

Waiters, sales clerks and hotel workers who live here year-round just laugh at inquiries about the town's tempestuous geology, and many said they don't even notice tremors that shoot helicorder needles to the 4.1 mark.

Dan Moran, a U.S. Forest Service worker, reiterated the remarks from many local ski enthusiasts: "They say, 'Who cares. If it blows, there'll be more vertical feet.'"

"If something happens," said one restaurant worker, "it just happens. There's not a damn thing we can do about it."

Jerry Cushen, president of the chamber, responded to inquiries about the volcano by saying, "An earthquake could happen in San Diego at any moment, too."

So many tourists have come to the town this summer and fall asking how they get to see the lava, the town has a new nickname, worn somewhat facetiously on auto bumper stickers: "Mammoth Quakes."

Yet despite local skepticism, geologists, volcanologists and hydrologists from state and federal agencies

and a dozen universities or research laboratories from here to Canada are concerned enough to poke holes in the ground, measure distances between rocks, set up infrared devices and take samples of water, soil and gas to learn everything they can.

They've established tilt meters, a network of geodetic lines, hydrogen gas detectors, seismometers, sophisticated "electromagnetotelluric" sensing devices and have arranged to relay the results to analysts by radio signals and satellite beams. The research alone is costing taxpayers a bundle, scientists said.

As Marc Clarke, a U.S. Forest Service hydrologist who collects some of the data and personally observes some of the hot spots daily or weekly and recently spotted nearly a dozen new boiling springs Dec. 13, remarked, "It's like a little research laboratory up here these days."

Their cause for concern was prompted by a number of events that have rattled the ground during the last three or four years.

The incidents — such as the 6.1 Richter scale earthquake of May 25, 1980, the ensuing 300 smaller tremors during the next two days and the emergence of hot bubbling pools where none existed before — have led researchers to suspect that perhaps, just maybe, the great volcano is ready to blow again.

Areas of the ground have warmed up enough to kill trees, and seismologists note that spasmodic tremors appear centered in one area, about a mile in diameter around the Sherwin Creek Campground.

"I would be disappointed," said USGS geophysicist Robert Cockerham in Menlo Park, "if something didn't happen in my lifetime. There's just too much going on."

Chances look good, he said, that if the volcano doesn't hit first, then a massive earthquake will, and relatively soon.

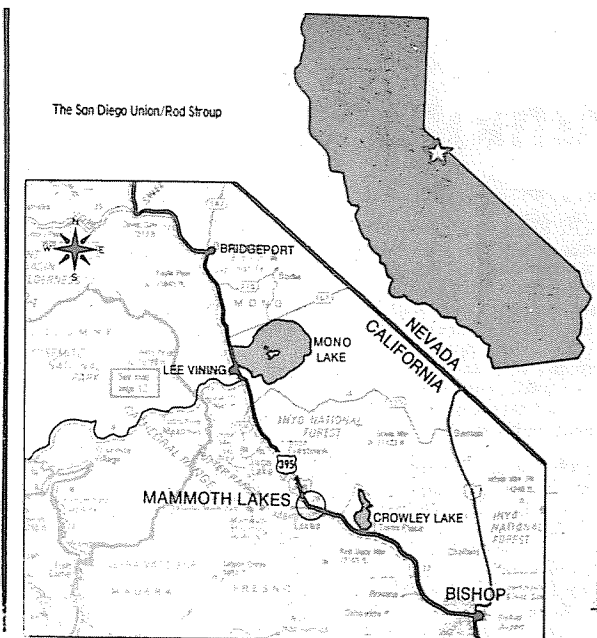
In fact, the height of the dome of the old collapsed volcano and other domes in the area northwest of Crowley Lake have risen as much as 35 centimeters or almost 14 inches since 1980, indicating a possible intrusion of one kilometer of magma between one and two miles below the surface beneath an area very near the intersection of Highways 203 and 395, researchers say. The rise appears like a pimple atop a volcano.

The notice the USGS issued last May was actually the first and lowest stage of a three-stage system of warning about a possible eruption.

The notice indicates simply that scientists think the history of the area is such that an event is possible, explained Al Leydecker, a civil engineer and geothermal expert formerly with the Forest Service who has made Mono County's geology his personal project. No one is suggesting that anyone change plans, move anywhere or stay away.

The next stage, he said, is the "watch," which tries to put a handle on size and predict the timing of the ejection within years and months.

The third and most ominous alert, he said, is called a warning, in which experts would bring the timing estimate down to weeks and days.



Actually, Leydecker said, since the notice was issued after scientists had time to analyze data gathered since the 1980 earthquake, he thinks the USGS is more accurately between a first and second stage, and soon will be able to take a stab at prediction.

Leydecker, who shows films and writes articles about the phenomenon, said the area has experienced 40 minor eruptions in 2000 years, with major ones in 200 to 300 year cycles. The last one, he said, was dated at about 200 or 300 years ago.

Sitting in his trailer home about a mile from the area of greatest suspicion, Leydecker regards the entire affair as "like a detective story with a bunch of clues."

The plot of that story, the big scientific question, he explained, revolves around the question of which came first: the chicken or the egg. Are these tiny earthquakes actually cracking open fissures to gouge a path for the molten magma, as many seismologists believe?

Or is the sloshing hot magma releasing energy that's causing the swarm of earthquakes, as many geologists and volcanologists contend?

Perhaps, Leydecker observed, there's a bit of truth in both. Maybe both the magma and the tremors have a common derivation.

Or, offered Moran, who works at the U.S. Forest Service ranger station only a few miles from the area of all the excitement, what's going on may just mean the magma is simply

going away. For the time being.

The level of scientific knowledge, despite all the digging and measuring, is far from conclusive. "We can't say we know for sure that at this one spot the magma is emerging," said Cockerham. "And we probably really won't know until it happens."

"Just about anything we come up with is inspiring," said Roger Shurburne, a seismologist with the state Division of Mines and Geology.

Nevertheless, most researchers are optimistic that the community will have a day or two of warning through the eruption of "precursors," which they suspect will take the form of large-scale bubbling ponds called fumaroles, from which gases or steam might emerge. "But that's a guess," Cockerham said candidly.

What Leydecker, who was so concerned about the town's reaction to the news that he ran for a seat on the Board of Supervisors last summer and won, worries about is whether the "adequate warning" scientists hope will come will be conclusive enough to make the decision to tell tourists to stay away, and people already there to leave.

There has even been talk about setting up a survival center, ironically at one of the large Mammoth Mountain ski warming huts.

"We know," Leydecker said, "what has occurred; what it means for us now is a whole different thing."

"You can't deny the evidence," said Moran. "Someday, something's going to happen."

THE SAN DIEGO UNION
Monday, January 3, 1983

JUMBLE THAT SCRAMBLED WORD GAME

Unscramble these four Jumbles, one letter to each square, to form four ordinary words.

S N A I E

C E H K T

C L E B U K

G I D I N O

Answer: THE

Don't worry, we've got insurance



THE FIRST THING THEY SAW WHEN THEIR HOUSE WAS HIT BY AN EARTHQUAKE.

Now arrange the circled letters to form the surprise answer, as suggested by the above cartoon.

Tremors quiet in Mammoth

Associated Press

SAN FRANCISCO — Some of the geologic activity that has scientists worried about a possible volcanic eruption near the High Sierra resort of Mammoth Lakes has tapered off a bit.

But scientists said Saturday they still don't know nearly enough about what's happening to put anyone's mind at ease.

"I wouldn't want to say there's any cause at this point ... or to tell people there's any less potential for an eruption," said Roy A. Bailey, head of the U.S. Geological Survey's volcanic hazard program at Reston, Va.

"I don't feel we can say we really know what's going on there ... and I don't think there's any reason to say they're any better or worse off than they were last May," Bailey, who has studied the area extensively, said in an interview during an American Geophysical Union conference.

On May 27, the USGS issued a "notice of potential volcanic hazard" — the lowest of three levels of official concern — for the Mammoth Lakes area, located eastward across the Sierra Nevadas from Yosemite National Park. It has a million-year history of many volcanic explosions.

No one has ever predicted an eruption will occur, and geologists have stressed the activity could end harmlessly.

Nonetheless, most agree a potentially disastrous eruption is possible — in months, years or decades — and state and local agencies have begun a major planning effort to prepare for the possibility.

Alan Ryall, the University of Nevada seismologist who first reported the earthquake patterns, said at a conference session on Mammoth Lakes, "The process

is slowing down in the sense that we haven't seen any spasmodic tremors (continuous bursts of small quakes that have preceded volcanic eruptions elsewhere) for seven months now and the overall seismicity has decreased.

"The level remains high (compared to the 1970s), but it's not superhigh."

Bailey said, "The very fact we're not seeing spasmodic tremors suggests that if (those that caused concern over the past two years) represented injection of magma (near the surface) it's probably not continuing."

But whether such movement has really stopped and whether it might start again "is a big unknown."

Bailey also said seismic activity, especially swarms of small quakes which, along with spasmodic tremors, had been concentrated in an "epicentral area" scarcely two miles from the popular skiing and fishing resort of Mammoth Lakes, seems to have shifted eastward. He said the three most recent swarms, one in each of the past three months, were scattered several miles east of the area.

The USGS warning cited two years of abnormal behavior that first attracted attention with a series of four large earthquakes May 25-27, 1980. Seismic activity, which began increasing in 1978, remained very high after that.

Santa Barbara News-Press
January 5, 1983

Small quake jolts

Sierra Nevada area

MOUNT SHASTA (UPI) — A small earthquake was widely felt by residents in the Sierra Nevada foothills and swayed building and ski equipment at Castle Crag National Park Tuesday but caused no damage.

A spokeswoman for the U.S. Geological Survey in Menlo Park, said the earthquake, which hit at 1:18 p.m., measured between 3.0 and 3.5 on the Richter scale.

Bakersfield Californian, January 7, 1983

Quake series causes Mammoth area panic

MAMMOTH LAKES (AP) — A series of strong earthquakes centered along the eastern Sierra rocked a wide area of central California Thursday afternoon, knocking groceries off store shelves and triggering brief panic in a restaurant.

The quakes, beginning after 5 p.m. and centered in the seismically active Mammoth Lakes area, caused power outages in the resort and were felt 100 miles to the west in Fresno and Merced, authorities said.

The strongest earthquake in the Mammoth Lakes series — 5.5 on the Richter scale — was felt in the Bakersfield area at 5:38 p.m.,

reported technician Kathy Watts in the California Institute of Technology at Pasadena. Although this area received the ripple effects of the quake, a tremor of magnitude 5 can cause considerable damage in the epicenter.

No injuries or major damage were immediately reported.

"It came in first in our instruments near Mammoth Lake," said University of Nevada-Reno seismologist Wally Nicks. "The main shock seemed to be more than a five (on the Richter scale). I don't know how much more. There are so many earthquakes coming in we can't distinguish it right now... just

continuous earthquakes. I'd guess it's someplace between 5 and 5 1/2."

The quakes knocked out power at the Mono County sheriff's substation in Mammoth Lakes and other spot outages were reported, said a deputy who did not identify himself. Numerous calls were coming into the station, which was operating on emergency power, the deputy said.

"People are shaken up really badly," said January Silberstein, an employee at the Chart House Restaurant in Mammoth Lakes. "There's a feeling of semi-panic in the rooms, but people are fighting it."

Another shaker hit as she was talking over the telephone.

About 50 people in the restaurant when the first quake hit "just ran to the middle of the room," she said. Power was knocked out for two minutes.

She said the quake jostled dishes and spooked chandeliers.

"We had a couple of pretty good jolts," said Don Austin, manager of a Gateway Market in Mammoth Lakes. "Things are off in the aisle, power's off in the upper part of town."

The Mammoth Lakes region has been beset by hundreds of small earthquakes in the past few years and may be ripe for volcanic activity, says the U.S. Geological Survey.

The USGS recently reported that a 4 1/2-square-mile underground chamber full of partially molten lava is inching its way toward the surface and increased seismic activity could fracture the earth's surface and produce a volcano.

Los Angeles Times, December 14, 1982.
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Seismic Activity Decreases in Mammoth Lakes Region

By a Times Staff Writer

SAN FRANCISCO—Winter has settled on the Mammoth Lakes area in the eastern Sierra Nevada and so has a decrease in seismic activity suggestive of a developing volcano, a U.S. Geological Survey scientist said here Monday.

Roy A. Bailey, who has been studying the region for several years now, said "it's relatively quiet at the moment and we sort of expected that because of the season." In winter, he explained, seismicity tends to drop off as the water level drops.

In the spring and summer, as the snow and ice melt and the water

percolates down through the soil, it acts as a lubricant of sorts.

Although small earthquakes continue to bump the Long Valley area, where Mammoth Lakes is located, from time to time, they do not seem to be opening up the crust to a rising tongue of magma.

Bailey said the volcano "notice" issued for Long Valley last May, the lowest of three hazard warnings put out by the USGS, would remain in force "probably for the rest of our lives."

A brief respite from activity should not be misinterpreted as an end to potential volcanic hazards, he said.

Fri., Jan. 7, 1983

ST. LOUIS POST-DISPATCH

Quakes Cut Power At California Resort

MAMMOTH LAKES, Calif. (AP) — The ground trembled fitfully under this mountain resort early today after two sharp quakes caused power outages and "semi-panic."

Hundreds of quakes, felt across a wide area of central California, began at 4:26 p.m. Thursday with two sharp tremors and aftershocks continuing at a rate of at least 50 an hour.

They continued early today but slackened "in frequency and magnitude, maybe 25 or so an hour

now," said Don Finley, spokesman for the U.S. Geological Survey National Earthquake Information Center at Golden, Colo.

Preliminary measurements of the quakes ranged up to 5.6 on the Richter scale of ground motion.

No injuries and little damage were reported. But the quakes triggered alarm and prompted some resort guests to leave, authorities said. The eastern Sierra region is 200 miles east of San Francisco.

Hundreds of Quakes Jolt Mammoth

By JOHN KENDALL and GEORGE ALEXANDER, Times Staff Writers

A swarm of earthquakes knocked out electric power and telephone service in the Mammoth Lakes area of the eastern Sierra Thursday night, but there were no immediate reports of injuries or major damage.

The Caltech seismology laboratory said there were "hundreds" of tremors ranging from the almost-imperceptible to several in the potentially damaging range. The largest registered 5.6 on the Richter scale.

The quakes continued into the early morning hours today but were of reduced intensity.

Jerry Eaton, a spokesman for the U.S. Geological Survey at Menlo Park, said the epicenters appeared to be in the Sherwin Creek campground area—the place pinpointed as a potential "volcanic hazard" by his agency last year.

'Spasmodic Tremor'

At the Reston, Va., headquarters of the Geological Survey volcanologist Roy A. Bailey and seismologist John Filson set up an emergency command post in the early evening hours.

Bailey, who has been conducting a study of the volcanic hazards of the Mammoth Lakes region, described Thursday's quakes as "the most dramatic seismic activity we've seen there to date."

The small earthquakes were popping in such numbers and so close together that they constituted what earth scientists call "spasmodic tremor." Spasmodic tremor frequently occurs before a volcanic eruption, although not every instance of such

shaking is necessarily followed by a blast.

Bailey said the sudden outbreak could be simply another big swarm of seismic activity, which will die out as have previous swarms, or it could be the start of a more serious development. "We just don't know at this point," he said.

In the vicinity of the quakes, however, such questions seemed academic Thursday night as the earth continued to move and lights flickered on and off.

Mono County Sheriff's Deputy Jeff Mills said that a lot of people were making "a mad dash down the highway, going south (on U.S. 395)," and "I can see a lot of tail lights from where I'm sitting. . . ." The Mammoth area is usually packed with skiers at this time of year.

Southern California Edison Co. said about 1,000 customers in the vicinity of the quakes lost power with the most severe tremors, but most had electricity again within three hours.

Last May, the Geological Survey issued a "notice of potential volcanic hazard" for the region, meaning that certain features were present indicating possible emergence of a volcano in the area.

Asked if the USGS was going to recommend to state officials the evacuation of Mammoth residents and visitors, Bailey said: "No. We're in contact with them and the U.S. Forest Service in Bishop. And through a radio link in Bishop—because all the phones in Mammoth are out—to the sheriff's station at Mammoth."

Geological survey seismologist Rob Cockerham said in Menlo Park a preliminary analysis of the thousands of small earthquakes and the few large shocks did not suggest that their epicenters were rising to the surface. Were that to happen, the scientists would tend to interpret it as a sign that the tongue of magma was pushing upward and that an eruption might therefore be likely.

State Looks For Volcano, Quake Link

□ Fountains of fire shoot 500 feet high from the Kilauea volcano in Hawaii in a "major eruption." Page A9.

By Stephen Green
Bee Staff Writer

Earthquake swarms in the Mammoth Lakes area during the past two days have been centered near an area where a volcano may be developing, state and federal geologists said Friday.

"We don't believe there is a danger at this time," said state geologist Jim Davis. "We're not definite on whether they (the earthquakes) are volcanically related. . . . But they should be watched very closely as though they are volcanically related."

Both state and federal geologists have been sent to the scene, Davis said. They'll be checking for signs of change that could be related to molten rock working its way toward the surface. That includes watching temperatures in hot springs and mud pots, looking for new geysers and measuring the ground to see if it's bulging anywhere.

Charles Bacon of the U.S. Geological Survey in Menlo Park said the scientists should be able to determine from seismographs what type of tremors were occurring near the eastern Sierra Nevada community. But that will require detailed study.

Hundreds of earthquakes coming one after another have left jumbled lines on seismograph charts. Volcano-induced quakes tend to produce a seismic pattern differing from quakes caused by rocks shifting in the earth.

Most of the quakes were centered near Highway 395, about three miles east of the ski resort town, said Austin Wilson of the University of Nevada, Reno, Seismological Laboratory. Wilson said the location is a brushy plain about 1.5 miles from a so-called "epicentral" site identified last May as "the second hottest vol-

canic site in the conterminous United States after Mount St. Helens."

At the time, the Geological Survey issued a notice saying that a volcano was likely at the epicentral site within the next 50 years.

Geologists think that a chamber of semimolten rock is about two miles below the surface. It appears that a tongue of hot rock is working its way upward through cracks and fissures.

Mammoth Lakes is about 250 miles northeast of Los Angeles on the edge of an ancient volcano caldera. It exploded about 700,000 years ago in one of the world's greatest eruptions. The Long Valley, the 12-by-18-mile-wide hole left from that eruption, has been volcanically active at varying intervals since. The last documented eruption in the vicinity was about 230 years ago.

Signs of new stirrings beneath the caldera have been recorded for more than two years. As Mount St. Helens was exploding 800 miles northward in May 1980, Mammoth Lakes was being rocked by a series of quakes — some of which were more than 6 on the Richter Scale.

Two quakes Thursday evening were near 5.5, Wilson said, and aftershocks were still occurring about one per minute Friday. Most of the aftershocks, however, were only 1 or 2 on the scale.

Bacon said that if this earthquake sequence follows past patterns, the shocks will be coming only occasionally today and will be gone within two weeks.

Thursday's shocks collapsed a hangar on top of a twin-engine plane at the Mammoth Lakes Airport. Dishes and canned goods tumbled off shelves, and about 1,000 people were without power for a time. There was minor panic at one restaurant, but no injuries.

Some resorts reported that a few people had checked out and others canceled weekend reservations.

Mammoth Lakes has about 4,000 permanent residents. In ski season, however, it's not unusual for 50,000 people to be in the area. The only road out of Mammoth Lakes in winter is Highway 203, which joins the main north-south Highway 395 near the point of the epicentral site.

Swarm of quakes bothers California resort

By ROBERT LOCKE
The Associated Press

MAMMOTH LAKES, Calif. — Hundreds of earthquakes rumbled for a second day Friday through this Sierra Nevada ski resort, which since May has been under official notice of "potential volcanic hazard."

Geologists stressed they haven't determined whether the earthquakes were associated with underground volcanic activity.

More than 1,000 earthquakes were recorded in the first 12 hours of the swarm that began Thursday afternoon, including two strong tremors that caused minor damage, geologists said. Groceries fell from shelves, power outages were triggered and an aluminum airport hangar collapsed.

No injuries were reported, but the largest of the quakes panicked restaurant patrons and prompted some hotel and ski resort guests to leave the area, which is 200 miles east of San Francisco and 250 miles north of Los Angeles.

While several resorts said they received numerous calls Friday from potential tourists concerned about the

quakes, they said they expected normal business during the weekend.

"I don't think people are too worried," said Julia Fitzpatrick, manager of the Mammoth Lakes Chamber of Commerce. "People who have lived here for any time are used to feelings of small tremors."

Scientists said they don't know just what the current quake activity means and emphasized that no one is predicting anything. Similar swarms have shaken the area in the past few years, contributing to the U.S. Geological Survey's decision May 27 to issue its potential hazard notice, the lowest of three levels of official alerts.

"We are uncertain as to whether it is volcanic or tectonic" — associated only with earthquake faults, said California State Geologist James Davis. "The prudent thing is to study the matter intensively and make kinds of geologic observations that may help us."

Michael Jencks, chairman of the Mono County Board of Supervisors, said, "We have in place a disaster plan. All the agencies were in touch, closely monitoring the quakes. That

creates an atmosphere of confidence." Kathryn Lee, marketing coordinator for Whiskey Creek restaurant, where panicked customers ran outside as Thursday's quakes knocked out lights. "A lot of them just yelled and laughed it off — just tried to get out some emotion."

Southern California Edison reported that about 1,000 customers in the Mammoth Lakes area lost power with the initial tremors but most had power back within several hours. The largest of Thursday's two moderate jolts measured up to 5.6 on the Richter scale, said Don Finley, spokesman for the U.S. Geological Survey's National Earthquake Information Center at Golden, Colo.

The agency manned a command post through the night at its Reston, Va., headquarters, where volcanologist Roy Bailey described the swarm, most of which was too small to be felt except by seismographs, as "the most dramatic seismic activity we've seen there to date."

and Merced and 100 miles southwest in Bakersfield, authorities said. Tremors also were felt at Yosemite National Park headquarters northwest of Mammoth.

Most of the small quakes, occurring through the night at a rate of more than one a minute, were centered near a spot, called the epicentral area, that has been of greatest concern to geologists. The site near Sherwin Creek campground is about two miles from Mammoth Lakes and has been the focus of much previous earthquake activity.

Charles Bacon of the USGS center in Menlo Park center said scientists lack enough information to decide whether the quakes are associated with any underground movement of partially molten rock, which some scientists had blamed for previous swarms.

Hundreds of quakes have occurred in the area over past years, ranging from the imperceptible to a major tremor that registered 6.5 on the Richter scale in May 1980 and triggered rockslides that injured nine people.

Experts Flock to Quake-Hit Mammoth Area

By GEORGE ALEXANDER and JOHN KENDALL, Times Staff Writers

MAMMOTH LAKES—More than a dozen federal and state scientists, many carrying a variety of portable earth-measuring instruments, rushed into the Mammoth Lakes region Friday to conduct on-site investigations of the earthquake swarms that have been shaking the popular High Sierra resort area since Thursday and to make some assessment of what a plug of molten rock is doing just a few miles below the snow-covered surface.

More than 1,000 earthquakes have shaken the area since late Thursday afternoon. Most have been small, measuring only 1 to 2 on the Richter scale of magnitude, but there were two magnitude-5 events—5.5 and 5.6—within two hours of each other Thursday afternoon and evening. The activity has subsided, but scientists expect a low level of activity to continue.

No one has been injured, but store shelves have been overturned and a hangar at a nearby airport partially collapsed, damaging an expensive light plane.

Assessment Is Key

The scientific assessment of the geological situation—which could come sometime early next week—will determine whether the U.S. Geological Survey leaves standing its "volcanic hazards notice" for the Mammoth Lakes-Long Valley region, or upgrades it one notch to a "volcanic hazards watch."

The geological survey has three levels of concern for natural hazards—"notice," "watch" and "warning." Volcanologist Roy A. Bailey of the survey explained last May when the region was put on "notice," that a "watch," the next highest level of warning, "implies that we've recognized an active process (at work) instead of a static situation."

A "hazards watch" would mean that visitors and permanent residents of the Mammoth region would have to give serious thought to the possibilities of a volcanic eruption in the near future. That could be measured in a few years to a decade or more.

"We have talked about this," said California state geologist James Davis, about the possible upgrading of the region's status. "It all depends on how these investigations going on there now converge."

Suggestive Signs

Asked to define "convergence," Davis answered: "If there is a significant and persistent pattern of ground deformation in the epicentral area, that would be suggestive (of the magma, or molten rock, moving upward toward the surface). An abrupt change in fumarole or hot-spring activity; that too would be suggestive. And obviously, the depth of the epicenters (the subsurface focus of the earthquakes), is particularly important."

Davis said that if measurements now being made by the federal and state scientists in the field outside Mammoth Lakes Village all point in that direction, he would agree to the geological survey's upgrading action.

On Friday, a Mammoth Lakes cable television outlet broadcast a

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Los Angeles Times

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statement that the thousands of small and handful of medium-sized earthquakes felt since last Thursday "were purely seismic and not volcanic" in origin. The TV operator cited the state Division of Mines and Geology as its source.

But Davis, who heads the state agency, said flatly: "It's totally wrong. We have not put out a statement that the activity there is tectonic (related to motion-induced breakage of rock layers) and not volcanic."

And Bailey, reached at his agency's Reston, Va., headquarters, said, "There definitely was spasmodic tremor at Mammoth, up to the point where there were so many earthquakes they all ran together (on recording instruments) and could no longer be distinguished."

Spasmodic tremor is a particular pattern of seismic activity that sometimes precedes volcanic eruptions. It consists of closely spaced—in time and place—tiny tremors.

"We don't know the exact mechanism of spasmodic tremor," Bailey said, "but it involves frequent, low-intensity fracturing of rock. It's a lot of little rock layers all cracking as magma intrudes into those layers."

But, the volcanologist added quickly, it is possible to have spasmodic tremors and no subsequent volcanic eruption. It would be considered unusual, however, for the inverse to happen—to have an eruption without first experiencing spasmodic tremor.

Like Davis, Bailey said it was important to learn the results of the investigations now going on in the Long Valley Caldera, of which Mammoth Lakes occupies a relatively small corner. Some scientists for the geological survey have brought tiltmeters to the area and are now attempting to measure how much, if any, of the ground to the southeast of the resort village has been deformed by this outburst of earthquakes.

Others are using magnetometers to look for magnetic fluctuations, since variations in magnetic field strengths have sometimes been observed before volcanic activity in other parts of the world. Still others are measuring water levels and chemical properties and some are surveying the lengths of known lines to see if the resurgent dome—the remains of a stupendous volcanic eruption 700,000 years ago—has grown any as a result of these recent earthquakes.

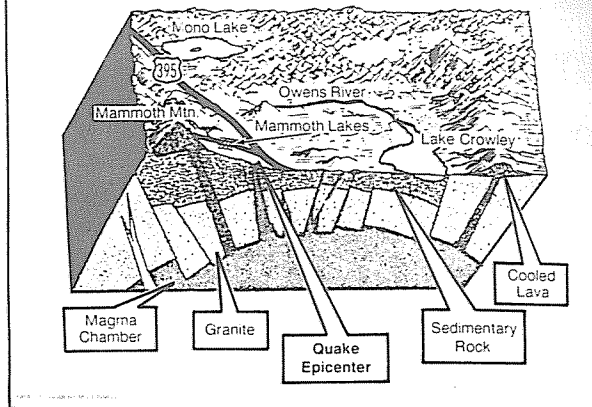
Although there is a sense of urgency about these findings—Thursday's swarm of earthquakes is the biggest activity since four magnitude-6 shocks hit the region over the Memorial Day weekend in 1880—there was also a sense of relief that the activity seemed to be tapering off Friday.

"I feel a little more relaxed (Friday) than I did the day before," Bailey said.

Meanwhile, thousands of skiers took to Mammoth's slopes under bright blue skies Friday.

Sacramento Bee

January 8, 1983



Geologists will be checking for signs of change that could be related to molten rock working its way to the surface.

Los Angeles Times

★★ Sunday, January 9, 1983

Skiers Hit Slopes Scientists Are Monitoring

By JOHN KENDALL, Times Staff Writer

MAMMOTH LAKES—Skiers flocked to the slopes of the thousands Saturday, without apparent worry over what has caused hundreds of earthquakes to shake this popular Eastern Sierra resort.

As scientists used tank-like snow cats to inspect monitoring stations in the area, 10,000 to 11,000 skiers tested the 89-inch base on Mammoth Mountain, which was in full operation.

"It looks like a real good weekend," said Pam Murphy, a marketing assistant for the Mammoth Mountain ski area.

The earthquake swarms that began Thursday afternoon continued Saturday, with slightly reduced frequency and at a somewhat reduced rate, according to spokesmen for the U.S. Geological Survey.

Scientists Collecting Data

Dr. C. Dan Miller, a survey volcanologist, said at a news conference Saturday that his department is not considering upgrading its notice of potential volcanic hazard, the lowest of a three-stage advisory system.

The scientist said there has not been enough of a change noted locally to advance the survey's advisory to a "hazards watch," the next-highest level of warning.

Miller said 30 to 40 scientists are collecting data at Mammoth Lakes to determine whether magmatic activity is taking place miles below the Earth's surface.

By late Saturday, the area was experiencing a magnitude 2 quake every 1½ to 2 minutes according to Rob Cockerham, a survey scientist at Menlo Park.

"Just a lot of little guys popping off," he said. Mark Zoback, another survey scientist at Menlo Park, said the small tremors can be expected to last for a while, "but we have no information that indicates the situation is becoming hazardous."

Still, Cockerham said, the outbreak of earthquakes, now in its third day, has to be related somehow to volcanic processes.

"I don't know of any tectonic (quakes caused by the movement of continental plates) activity quite like this that would last this long," Cockerham said.

Complete Picture Sought

Geologists hope to develop a complete picture of what is taking place by combining information gathered by earthquake-measuring instruments with data of possible physical changes in the area, such as ground deformation or increased heat flows from fumarolic hot spots or springs.

One of the teams that moved out Saturday morning to investigate epicentral areas from 1.5 to 4 miles southeast of here was headed by Arthur Sylvester, chairman of the Department of Geology at the University of California, Santa Barbara.

Sylvester and four senior geology students, Ken Gester, Elizabeth Nixon, Karl Gross and Michael Eunds, rode a snow cat to sites where they had earlier set up tilt-meter stations.

Their job was to detect any ground deformities that may have occurred since mid-December, when the sites were last visited.

They used sophisticated surveying instruments and



Associated Press

Geologists conduct tests

Continued next page

SLOPES: Skiers Show Little Fear

Continued from previous page

measuring rods to determine the relative position of three points previously examined at each of the tilt-meter locations.

Nothing Found During Aerial Flight

An aerial flight over the Long Valley Caldera, site of a catastrophic volcano eruption about 750,000 years ago, failed to disclose any out-of-the-ordinary distortion, Miller said. The caldera includes the Mammoth Lakes area.

To the usual question of whether there would be sufficient warning of a volcanic eruption for visitors and residents to leave the area, Miller said most volcanic activity in the past has been signaled by physical changes.

"It's likely that volcanic activity would be preceded by detectable deformation," the scientist said.

He said, however, that there have been instances of volcanic activity without warning, although it is not probable.

Asked whether he considers it safe to visit Mammoth Lakes, Miller said he could not estimate the level of risk but could only say that the Geological Survey is monitoring the situation and collecting data to make an assessment.

"I can't answer the question in terms of what people should do," he said.

Jeff Gordon, a Telemark skier who challenges the downhill slopes on cross-country skis, said he isn't concerned about earthquakes or potential volcanic eruptions.

Gordon said he thinks that permanent residents of Mammoth Lakes are used to earthquakes, and he said he expects plenty of warning if the resort is threatened by a volcanic eruption.

Gordon said he is much more concerned about the world being destroyed in a nuclear holocaust.

A hitchhiking Mammoth Lakes carpenter is not quite so sanguine about the local situation.

His wife is frightened, he said, and wants to leave the community.

Neither he nor his wife is frightened so much by earthquakes, the carpenter said, as by the possibility that a volcanic eruption might cut off California 203, the only paved, snow-plowed road connecting the ski resort with U.S. 395, the main north-south highway.

Michael Jencks, chairman of the Mono County Board of Supervisors, told reporters Saturday that he thinks the latest outbreak of earthquakes has affected business somewhat, but not to a "substantial" degree.

Contributing to this story was Times Science Writer George Alexander.

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California quakes continue

By ROBERT LOCKE
The Associated Press

MAMMOTH LAKES, Calif. — "A continuing string of small earthquakes may signal volcanic activity in the rugged mountains around this high-country ski resort, a geologist who studies volcanoes said Saturday.

But C. Dan Miller and other scientists stressed at a news conference no one is predicting an eruption in this community along the eastern slopes of the Sierra Nevada, across the mountains from Yosemite National Park.

"Our level of concern (about volcanoes) is above our level before this last earthquake swarm," Miller said. "That's a very general statement."

Small quakes continued to jolt the region 200 miles east of San Francisco and 250 miles north of Los Angeles

for the third straight day Saturday.

"We're all wondering just what's going on at depth (several miles beneath the surface) and just what the mechanisms are" that produced the quakes that began Thursday afternoon, said geologist Roger Martin of the California Department of Mines and Geology.

"The low-level seismic activity is persisting with frequent small magnitude earthquakes," said geophysicist Mark Zoback at the U.S. Geological Survey offices in Menlo Park.

"There have been several felt earthquakes, approximate magnitude 3 to 3.5 (on the Richter scale), in the last 24 hours, but there have not been larger events such as those which occurred Thursday night," he said.

Scientists had been con-

cerned that similar previous earthquake swarms and other geologic changes might reflect molten rock moving several miles beneath the ground.

The latest swarm of quakes began Thursday afternoon and continued well into Friday, hitting at a rate of more than one a minute. While most were too small to be felt, two moderate tremors late Thursday did minor damage at Mammoth Lakes and caused the collapse of a hangar on a private plane at the nearby airport.

Miller, who was coordinating the scientific research on the snowy slopes from a communications center at the Mammoth Lakes Fire Department, said crews were trudging through the deep snow to remeasure survey lines, check for bulges in the earth, and look for new hot springs and steam vents.

As earth trembles, evidence grows that old volcano may be coming to life

MAMMOTH LAKES (UPI) — Swarms of earthquakes that have rattled the high Sierra in recent days are related to underground magma flow and possible activity from an ancient volcano that is altering the ground, officials said Sunday.

It had been suspected, but not previously confirmed, that the more than 2,000 quakes that have rocked the area since Thursday at the rate of one every one or two minutes, were portents of possible volcano eruptions.

"The U.S. Geological Survey says the quakes are related to magma flow," and not normal seismic activity, said Donna Perez of the interagency office at Bishop.

A news release jointly issued

Sunday afternoon by the geological survey and the Mono County Board of Supervisors noted that the nature of the quakes "continues to suggest" a magma flow source, she said.

Most of the quakes have registered about 1 on the Richter scale, too small to be felt, but tremors large enough to be detected continued to jolt tourists and residents several times a day. There were four such tremors Saturday night and Sunday morning registering between 3 and 3.5.

C. Dan Miller, volcano hazards assessment coordinator for the geological survey, said scientists using laser instruments had detected changes in the Earth's surface in the region where the quakes have been

centered, just south of the intersection of Highways 395 and 203 — the main thoroughfares into the popular ski resort of Mammoth Lakes.

The roads are the only way out of the area during the winter, but Michael Jencks, chairman of the Mono County Board of Supervisors, told concerned residents attending a meeting Sunday that the board would decide later this week whether to plow an escape route over the dirt logging roads that are normally covered with snow and closed this time of year.

Scientists continued to stress there was no immediate danger to town or its residents, although there was no guarantee that an emergency would be preceded by long periods of danger signs.

The laser instruments — set about three miles apart — detected a lengthening of 1.7 inches in the earth's surface during readings taken Saturday, Miller said.

He added that three of the five tiltmeters in the area, which measure the ground's movement, had registered "incredibly minute" changes in the area of small fractions of a millimeter.

"We don't know the significance at this point," Miller said, adding it was unclear whether the shifts could be interpreted as danger signals.

Scientists said they had

(San Fernando Valley) Daily News, January 10, 1983

found any signs of harmonic tremors, which indicate magma — molten rock — is rising to the surface. Harmonic tremors were felt previous to the eruption of Mount St. Helens.

Geological survey spokeswoman Perez said there would be no evacuation of area residents until an eruption is imminent.

An old volcanic crater, the remains of a giant eruption 700,000 years ago, lies five miles

below the area's surface. It rose 10 inches between 1975 and 1980, most significantly after four quakes hit the area in May, 1980.

Interest in the area grew Thursday when a series of tremors, measuring up to 5.5 and 5.6, rocked the area, 180 miles east of San Francisco.

At the time it had not been positively determined whether or not the quakes resulted from hot molten lava boiling up from deep in the earth.

Sunday, the scientists indicated they had little doubt.

Miller said it had been 50,000 years since a volcano erupted in the immediate area, although there were eruptions at Inyo Crater, about 50 miles away, as recently as 350 years ago.

Jencks said the quakes have not frightened off many skiers.

The drop has "not been substantial," he said. "It's a few percentage points off from the previous week."

Quake activity at Mammoth dwindles

MAMMOTH LAKES (AP) — The earth shuddered for the fifth straight day in the High Sierra Monday, but scientists said earthquake activity was dwindling and might be reducing the potential risk of volcanic activity.

"We are seeing a decrease in the number of magnitude one-to-two earthquakes," said Marianne Guffanti, a geologist with the U.S. Geological Sur-

vey in Menlo Park. "These are the small low-level earthquakes."

Weekend activity in the popular ski resort was down only slightly, business reported, despite the continuing shakers.

Ms. Guffanti said scientists didn't know why the tremors were diminishing.

"This could be interpreted as the Santa Barbara News-Press January 10, 1983

subsurface process coming to a point of equilibrium, and that would seem to indicate less of a danger of volcanic eruption," she said.

About five to six shakers between magnitude two and three were still being recorded each hour, with few above magnitude three, she said. During the height of the swarm of thousands that began Thursday night, small quakes were shaking the ski resort 30 to 40 times per hour.

The smaller quakes — many of which can't be felt — haven't caused any reported damage, but two tremors measuring 5.5 and 5.6 that jolted the area Thursday evening knocked out

power briefly, collapsed a hangar onto a private plane and tossed merchandise from store shelves.

Although some volcanic activity is believed to be occurring, scientists have said it could be a movement of magma — molten rock — deep below the surface and might not involve any volcano danger. Since the area is also riddled with earthquake faults, it has not been established what is causing the tremors.

"The Long Valley area has had a lot of volcanic activity in the past, say in the last million years or so. So we know that this is an area of active vulcanism," Ms. Guffanti said

Monday, January 10, 1983 ★

Los Angeles Times

Scientists Busy at Mammoth Lakes

Tests Indicate Volcanic Action Causes Quakes

By GEORGE ALEXANDER, Times Staff Writer

Slight deformations in the snow-covered ground have convinced scientists that volcanic activity beneath the Mammoth Lakes region is almost certainly causing the almost non-stop small earthquakes that continued for a fourth day Sunday.

What they cannot tell so far is how or in what direction the blob of molten matter beneath the surface is moving—or what the immediate future holds for the popular ski resort in the eastern Sierra.

"It's a very complex picture," said C. Dan Miller, a volcanologist with the U.S. Geological Survey, who hurried to Mammoth from his Denver office when the earthquakes began Thursday, "and we really don't understand what's happening."

Miller, reached by telephone, described how one team of scientists had surveyed a set of pedestal-like "bench marks"—whose positions have previously been pinpointed with great accuracy—in a field south of Mammoth Lakes Village. They found that the distances be-

tween these points have lengthened by an inch or two.

"That change is small but significant," Miller explained, "because it has taken place in just the past three weeks. That's when these lines were last run (surveyed)."

Scientists think the increased distances between the pedestals mean the ground has become slightly extended—either by spreading or by bulging upward. That is what they would expect to happen if a molten mass was forcing its way into overlying layers of cold, brittle rock.

Another team of scientists set up tilt-meters, similar to carpenter's levels, at five sites near areas where the majority of the 2,000 or so small temblors have been concentrated—about one mile southwest of the intersection of U.S. 395 and California 203. They detected changes at three places. Differences in the tilt are also taken as a sign of a crust undergoing deformation.

"The two sites where they didn't find any changes are close to the

three where they did," Miller continued, "so you can see what kind of a confusing situation we're facing up here."

Although Miller and other scientists may not know what the magma, or molten blob, is doing several miles down below, they did restate their belief that any eruption would probably be preceded by days, weeks or even months of advance warning. Still, they cautioned, there is no guarantee that science understands volcanoes well enough to predict eruptions.

There were signs of another kind around Mammoth Lakes: more and more local residents are beginning to address the possibility of a volcanic eruption more seriously than they have in the past.

At a public meeting involving several scientists and local elected officials, one resident asked Michael Jencks, the new chairman of the Mono County Board of Supervisors, about the need for an alternative escape route out of Mammoth Lakes

Village. At present, the only road into, or out of, the small community is California 203.

Jencks told his questioner that if the earthquakes continued, then serious consideration would have to be given to opening a second road.

As of Sunday afternoon, Survey scientists at Menlo Park, near San Francisco, reported there had been a marked decline in the number of tiny temblors in the magnitude 1 to 2 category, although earthquakes in the magnitude 2 to 3 range were continuing. Indeed, there were four magnitude 3 to 3.5 shocks throughout late Saturday evening and early Sunday morning.

"My guess," said David Hill, a survey scientist at Menlo Park, "is that it is beginning to die out. But we have had so little experience with this sort of thing that it's hard to say anything definitive."

Times staff writer John Kendall contributed to this story.

Santa Barbara, Calif., News-Press, Tuesday, January 11, 1983

Fear of eruption lessens at resort

MAMMOTH LAKES (AP) — As fewer and smaller earthquakes rumbled through this popular eastern Sierra ski resort for the sixth day today, scientists said the danger of a volcanic eruption was diminishing.

However, they said they still aren't sure what has caused the thousands of tremors that have jolted the area since Thursday.

"They're continuing at a decreasing level, about one every 10 minutes or so," seismologist Fred Klein of the U.S. Geological Survey in Menlo Park said today.

"There's been a kind of a steady decrease over the last couple of days," Klein said. "Occasionally, we'll have a magnitude of 3 (on the Richter scale), but only a few per day. Most of them have been between 1 and 3 on the Richter scale."

Between five and six low-intensity quakes an hour were recorded Monday morning, USGS geologist Robert Cockerham said, and seven or eight an hour Sunday. At the peak of the earthquake swarm that began Thursday night, small jolts were shaking the popular ski resort 30 to 40 times per hour.

Cockerham said the cause of the quakes was almost certainly magma — molten rock — shifting below the surface of the Sierra Nevada, rather than simple movement of the faults that riddle the area.

Back from a weekend's work in the Mammoth Lakes area, where light earthquakes have rumbled continually since Thursday, UCSB geology Professor Arthur G. Sylvester said there's no way to tell now if there will be a

volcanic eruption in the area.

Chairman of the campus's geological sciences department, Sylvester was accompanied by Karl Gross, Elizabeth Nixon, Michael Bunds and Ken Gester, all undergraduate geology majors. The UCSB team was one of several investigating the scene as the quakes persisted.

"Each individual and each group was working on slightly different things," Sylvester said. "We went to determine if there was any ground deformation — up-bulging or off-setting that could be seen by tilting (of the ground surface)."

Last spring and early summer Sylvester's team placed benchmarks in an area that has experienced considerable seismic activity, and had resurveyed them about every month since then.

"This past weekend, we surveyed half of them and members of the U.S. Geological Survey worked on the other half, because there was a lot of snow and it took a lot of time to gain access to the benchmarks. To get any kind of answers, we have to compare our reports with the theirs," he explained.

"That will tell us what the pattern of ground movement is, if any," he said.

Reports were turned over to a coordinating group, and the information obtained by Sylvester's team also must be compared to reports turned in by the seismologists and volcanologists on the scene.

When the results are in, he said, "We might have some more confident idea of what's going on. My idea is that there may be magma moving, causing the earthquakes. Or earthquakes may be causing magma to move."

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Crews Building Escape Route in Mammoth Area

Even as the number and magnitude of the earthquakes in the Mammoth Lakes region continued to decline Monday, Mono County road crews were opening up a second road into the popular Eastern Sierra ski resort as an emergency escape route in the event of a volcanic eruption.

Called Dry Creek Road, it is an approximately six-mile-long loop

that is part dirt, part oiled surface and part paved highway that comes out of a section of Mammoth Lakes Village known as The Knolls and cuts behind a ridge to connect to U.S. 395.

Michael Jencks, chairman of the Mono County Board of Supervisors, said in a telephone interview that three miles of the new road—starting at the intersection with U.S. 395

and running to the west—are already clear, because of an ongoing timber sale there. Loggers are hauling trees out and the road is passable, at least for that stretch.

County public works crews began early Monday morning to clear, widen and straighten the other end of the road, to the point where it terminates at The Knolls.

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Predicting Potential Disasters: a California Model at Mammoth

Los Angeles Times
Sunday, January 16, 1983

By George Alexander

How would you feel if hordes of people suddenly appeared at your elbow one morning and watched your every move as you sought to work? And what if some of these people were journalists, pestering you with endless questions, jabbing microphones in your face and tripping camera shutters?

Before you answer, consider this as well: How would you feel if, just as suddenly, your neighborhood was identified as the site of a potential disaster? Your street, your home with all its possessions, your neighbors—all threatened with catastrophe?

These are questions that a comparative handful of scientists, public officials and year-round residents are confronting today in the Mammoth Lakes area of the eastern Sierra, some 300 miles north of Los Angeles, where a glob of molten rock—called magma—moves uncertainly beneath the surface.

And these are questions that a great many more scientists and federal, state and local officials, as well as millions of other Californians, may have to confront tomorrow, as one of the state's major seismic faults grows increasingly knotted with strain and threatens to snap in a great earthquake.

In both these situations, the scientists are pushing hard to understand how these natural processes work. Such an understanding would become the cornerstone of the ability to predict when, where, how and with what likelihood a volcano might erupt or an earthquake strike. In both situations, public officials are being pushed to take responsibility for the political, social and economic consequences of such predictions. And in both situations, the general public is looking both to the scientists and to their elected representatives to lead them through the crises with minimal losses.

How realistic all these projections are, and how compatible they might be when an eruption or a great tremor is imminent, remains to be seen. Yet the experience of these three groups—scientists, government officials and citizenry—at Mammoth Lakes this past 10 days is grounds for reasonable optimism.

No sooner had two magnitude-5 earthquakes jolted the region in the late afternoon and early evening of Jan. 6, than U.S. Geological Survey scientists were on the telephone to both state and local officials. Earthquakes may be caused either by volcanic or tectonic (movement of

crustal plates) forces, but given the volcanic history of the Mammoth Lakes-Long Valley Caldera region, it is probably prudent to suspect the worst—that the earthquakes are somehow related to magmatic activity—until proved otherwise. Acting on that assumption, the scientists promptly got elected officials involved.

And kept them involved. USGS, state and university scientists briefed county officials each morning on the current status of the earthquake swarm. Michael

Jencks, the new chairman of the Mono County Board of Supervisors, then reported those findings to the press and any local residents in attendance.

One thing is clear: The scientific community is not going to assume the responsibility for notifying the general public about a developing hazard. There is a growing consensus among seismologists and volcanologists that their duty is to develop the predictive tools and to counsel

the political establishment on the likely significance of events like the recent earthquake swarm. It is then up to officials to decide upon appropriate responses, whether it is to evacuate communities, close schools, mobilize national guard or law-enforcement agencies, place public employees on alert, and so forth. "We have no authority to do the things that must be done in a crisis," a scientist once said to me, "and no one should expect us to reach for that authority."

For their part, public officials can be forgiven a grimace of pain when a volcanic or seismic prediction is suddenly thrust into their hands. Having to warn constituents of an impending calamity is not something to be done lightly, and the prospects of not only having to cope with the calamity, but with guiding the subsequent recovery as well, could discourage even the most resolute politician.

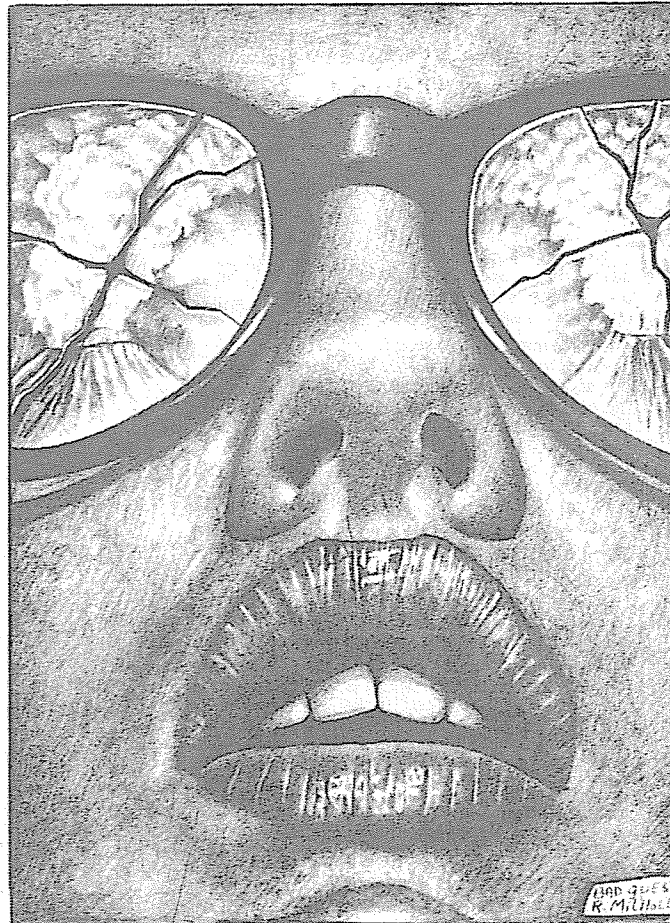
Another thing is clear: Politicians and businessmen will be tempted to press scientists for a delay in making public any notice of an impending hazard. Are you sure, really sure, about this prediction? Because if you aren't, they will continue, we don't want to put our necks on the line. Jencks and other Mono County officials resisted this stalling tactic, as far as is known, and from the start worked cooperatively with scientists.

As for the public, both Mammoth residents and other Californians may have to temper their expectations that science and government will save them from such hazards. There's no guarantee that volcanic or seismic predictions will be infallible.

The Chinese learned that lesson the hard way; they successfully forecast the walloping Haicheng earthquake of 1975, only to suffer a grievous loss of life in the unanticipated Tangshan shock a year later.

People will have assume much of the responsibility for their own survival in the event of a volcanic eruption or huge earthquake. At Mammoth, officials and townspeople have arranged to cut a second road into their popular little community and so now have an alternative route out of that alpine cul-de-sac, should an eruption occur.

Alternative escape routes are not nearly so helpful to those about to endure a large and destructive tremor, but there are equivalent actions that can and should be taken. No one wants to see Mammoth Lakes afflicted by volcanic eruption. But if that should happen, there are indications that the people are ready to cope. It would be reassuring to see similar indications of readiness in other parts of the state.



RICHARD MILDRELL / for the Times

George Alexander is a Times science writer.

... research indicates that the ground near Routes 395 and 203 has risen about 35 centimeters or 14 inches since 1975, and two miles from that point, north of an area called Casa Diablo Hot Springs, it has moved another 10 centimeters or 3.9 inches as of this summer.

Scientists Continue To Watch Mammoth

By CHERYL CLARK
Staff Writer, The San Diego Union

MAMMOTH LAKES — The helicopter lifted up for what must have been the 10th time that morning from the icy cold landing strip, again headed for the hard-to-reach ridges and canyons around and beyond 12,544-foot Bloody Mountain.

The chopper's somewhat dangerous mission, repeated dozens of times nearly every day last week, was to escort Frank Riley's team of seismologists, hydrogeologists and surveyors, and their 65 pounds of snowshoes and shovels, walkie-talkies and electronic measuring equipment, to one of the more than 80 monitoring points now dotting the peaks of this High Sierra wilderness.

Scientists coordinating their efforts with the investigation projects of other government teams estimated that since earthquakes again began rocking the town of Mammoth Lakes the afternoon of Jan. 6, more than 100 researchers had descended on the small resort community — all with the same purpose:

To determine whether the ski resort is about to explode in a hot lather of volcanic magma.

From the monitoring points, on narrow rock crags that jut precariously out of snow-banked cliffs, or on small mounds in the middle of vast open meadows, Riley and his United States Geological Survey subsidence research team from Denver and Tucson are trying, as best they can, to learn how close the magma chamber is to the surface and how big it is.

Most important, they want to find out whether the earthquakes, even though they have simmered down, have paved a route for a volcano that is just waiting for a moment to catch everybody by surprise.

For the scientists, the helicopter is a godsend. Without it, the scientists' research would be impossibly difficult. But it also is risky: A day earlier, a pilot and two USGS geologists on another research project were injured when another helicopter caught an unexpected gust and smashed into Laurel Mountain's 11,000-foot peak.

The helicopter carrying Riley's crew lifted up again and skipped over the steep ridges above Convict Lake, buzzed around the eggshell-like fuselage wreckage on Laurel Mountain long enough for a team member to get photographs and a good location description for a reconnaissance team. It then headed on toward several other narrow slices of mountain rock from which other USGS researchers, Mike Carpenter and Roger Denlinger, and several other team members were taking measurements.

When all were at their stations, the scientists begin a process called trilateration or distortion monitoring. They first locate the USGS's circular brass plate benchmark established during previous research expeditions, sometimes having to dig it clear of snow, and set up their delicate instruments so they are plumbed exactly in the center of the benchmark.

They then focus the instrument so that it projects a laser beam in such a way that the light beam is bounced back exactly to its source.

The beam may be focused over a distance as great as 15 kilometers, Riley said. It accurately measures to within three millimeters for every kilometer of distance.

The laser beam's trip back is timed by their equipment in such a way that by adjusting for weather conditions, barometric pressure and other phenomena — all of which must be measured at every station — Riley and his team can determine whether the magma chamber has changed or moved enough to cause a lateral movement in the ground.

Riley described the hot magma chamber as much like an underground balloon that is being inflated by a source of heat from below. Because the inflation causes a stretching of the ground, scientists are attempting to estimate the speed of that inflation — and thus the intensity of the magma chamber — by measuring the amount of stretching.

In the Mammoth Lakes area, Riley said, the strain from the upward lifting of the magma chamber has caused the ground to stretch as much as 50 centimeters or 19.5 inches since it was last measured in 1980.

Riley's current research will determine whether the ground has moved sideways any additional amount, and will be completed within the next few weeks.

It also will augment research presented in December at a San Francisco conference of geophysicists. In that paper, Riley and Denlinger tentatively estimated that the magma chamber is between four and seven kilometers beneath the surface. It is inflating, their research said, in the shape of a combined cylinder and sphere and it is directed upward.

By computer, their measurements will be dovetailed with the work of surveyors from the Los Angeles Department of Water and Power, which is using similar research strategies to determine the amount of movement in another dimension of the balloon: upward.

The LADWP, explained the city's

survey supervisor, Fenton Jones, is quite concerned that any volcanic eruption or dramatic seismic event could impair its supply of water bound for Los Angeles or its system of hydroelectric power, supplied to several mountain area towns and Los Angeles.

If LADWP's supply of water is impaired, they said, the city of Los Angeles might have to turn to the Metropolitan Water District of Southern California, which supplies water to San Diego. The right chain of events in an extreme disaster situation could mean a shortage for San Diego's water supply, they acknowledged.

Jones and LADWP's Duane Buchholz explained that a volcanic eruption could disrupt the 11.5-mile concrete tunnel that draws water from the Mono craters area into Crowley Lake or Grant Lake reservoirs. Or, they said, volcanic ash or lava flows could pollute the Crowley reservoir, making water from it undrinkable.

For those reasons, LADWP is using a measuring technique called "spirit leveling" to determine whether the surface area of the "resurgent dome" about 40 kilometers in diameter has risen again, and if so, how much. The resurgent dome is an area described as a bubble that is the area of greatest seismic suspicion.

So far, their research indicates that the ground near Routes 395 and 203 has risen about 35 centimeters or 14 inches since 1975, and two miles from that point, north of an area called Casa Diablo Hot Springs, has moved another 10 centimeters or 3.9 inches as of this summer. Measurements this week will study any movement since then.

All those calculations make sense when observed with a map of the epicenters of the hundreds of recent small and large earthquakes. Riley said the map takes the shape of a dumbbell, with a pair of epicenter clusters at either end. One cluster is near the Los Angeles YMCA camp just south of the intersection of Routes 203 and 395; the other is three miles southeast, not far from the eastern base of Laurel Mountain.

When Riley first heard that tremors were shaking packages off Mammoth's grocery shelves Jan. 6, he said, he wasn't sure that the team should take the time to come to Mammoth again. The summer's work had put in place what Riley called a "baby network" monitoring system, visited regularly by Marc Clarke, a U.S. Forest Service hydrologist who lives in the area year-

round.

Some equipment in the area regularly sends information to the USGS headquarters in Menlo Park, Denver or Reston, Va., by radio signal or satellite.

On top of that, his team had just been in Mammoth in mid-December taking further measurements.

Abandoning their work at the Denver office to come to Mammoth for more extensive measuring, he said, is an exhaustive project that monopolizes the USGS effort.

But when earthquakes continued to rattle the tourist community through the next day, he made the decision. "Judging from the magnitude of the quakes, and the continuing activity, it was the general consensus of the people in Mammoth that this was a very significant event."

By midnight Jan. 7, his team was on a plane bound for California.

He said the group's trip benefited additionally because they can be much more certain that any change between December's and January's measurements is caused by seismic activity rather than other sources of changes in the ground.

A week later, both the number and magnitude of earthquakes and their similarity with previous larger than usual earthquake swarms had convinced most of the researchers that the ground's activity was winding down and much of the volcano threat was subsiding.

By last Thursday, most of the researchers had packed up their instruments, cleared out of the Mammoth Lakes Fire Station's second floor, which had been turned into an emergency communications center, and boarded planes for home.

USGS geologist Don Mullineaux and chairman of the Mono County Board of Supervisors Michael Jencks noted that scientists had set up a new seismograph station and four new tiltmeters around the epicenter location, to provide more rapid data the next time the earth grows restless.

But when it does, Riley and his group as well as dozens of other teams, will be back on planes bound for Mammoth. They will be better prepared then, they acknowledged. In the meantime, they will plan to store equipment at Mammoth so they don't have to transport it from Denver, and arrange for emergency transportation. By then, a better communications system, complete with phone system that will have a built-in disaster line, will be in place.

In a way, Riley and his crew suggested, this December hurry-up research project has been like a dress rehearsal for a warning about the real thing.

When and if that will ever occur — the scientists agree — is anybody's guess.

Saturday, February 5, 1983 ★ Los Angeles Times

Quakes Shake Few at Mammoth

LOS ANGELES (AP)—Earthquakes were popping again Friday at Mammoth Lakes, where a swarm of temblors last month raised fears of possible volcanic activity. But a scientist said the latest shakers were causing little concern.

"This record (of small quakes that began late Thursday) does not look like what happened in January, or in any of the previous eight swarms" in the region, which has been volcanically active for millions of years, said Rob Cockerham of the U.S. Geological Survey's Menlo Park center.

The latest series of perhaps 100 quakes, which caused no reported damage, "are not in the immediate

area" of the swarm that began Jan. 6.

The January swarm sent dozens of federal and state geologists trudging through deep snow to monitor, measure and probe the earth around the Mammoth Lakes resort village. Cockerham said Survey geologists were not being dispatched in the wake of this activity, most of it about 1 1/2 miles southeast of Mammoth Lakes.

The largest of the tremors, a magnitude 4.5, occurred at 11:55 p.m. Thursday. Two of magnitude 3 hit during the night, followed by a 3.5 at 7:02 a.m. Friday and a 4.2 at 9:02 a.m., Cockerham said.