THE EARTHQUAKE OF JANUARY 30, 1934, AT EXCELSIOR MOUNTAINS, NEVADA*

By Eugene Callaghan and Vincent P. Gianella

Introduction

A moderately strong earthquake originated in the general region of the Excelsior Mountains to the southwest of Mina, Mineral County, Nevada, on January 30, 1934 (Fig. 1, Plate 23). It was felt as far west as Sacramento, California, and as far east as Salt Lake City, Utah. This shock is of particular interest as it is the fifth of a series of six moderate to strong earthquakes, exclusive of aftershocks, originating in the Great Basin during a period of fifteen months. A period of unusual seismic activity is indicated. The principal shock occurred at about 12:16 p.m. It was preceded by three foreshocks, one of which, at about 11:24 a.m., was sufficiently strong to be recorded by distant seismographs. The damage was relatively slight. Nevertheless, the following items may be listed: a few broken chimneys and the falling of a small section of brick wall at Mina, collapse of two walls of an adobe cabin at Marietta, partial destruction of stone cabin at Candelaria, cracks in concrete at Hawthorne, and destruction of a pipeline and pumphouse by rolling rocks at the Silver Dike mine in the eastern part of the Excelsior Mountains. There was no loss of life and no injuries were reported.

The region is characterized by mountain ranges, differing greatly in trend, which rise abruptly from inclosed basins (Fig. 2, Plate 24). The rocks, which are chiefly of Mesozoic and Tertiary age, include both igneous and sedimentary types and some intrusive masses. The summit area of the Excelsior Mountains north of Marietta is made up of volcanic flows and pyroclastics of probable Tertiary age dipping gently about N 25° W. Folded metamorphic rocks of probable Mesozoic age underlie the volcanics and outcrop prominently in the steep north and south slopes of the range. The summit area, as shown in Figure 3 (Plate 24), has a com-

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paratively mature appearance. Numerous faults occur within the ranges and along their margins. A rupture about 4,500 feet long occurred on one of these faults north of Marietta and is probably the surface expression of the movement that caused the earthquake.

The Principal Shock

According to press reports, the principal shock was felt over a large area, including many places in the Great Valley of California, numerous points in Nevada, and as far east as Salt Lake City. This earthquake was not felt so strongly, nor at such great distances, beyond the epicentral area as the earthquake of December 20, 1932,[1] which originated in the Cedar Mountain area some forty miles to the northeast. A preliminary determination of the epicenter at 38.2° north latitude, 118.6° west longitude, was furnished by the United States Coast and Geodetic Survey from instrumental data. This point lies in the Excelsior Mountains, to the west of Teel's Marsh, in the southwestern part of the Hawthorne quadrangle. The field investigation indicates that the strongest effects of the principal shock were noted in these mountains. Perceptible aftershocks were more numerous, stronger, and more persistent there than in the adjoining areas. Because of the sparse population and scarcity of structures no accurate determination of the strength of the shock was possible. It would probably be in the neighborhood of VIII or IX on the Modified Mercalli intensity scale.[2]

Reports of the direction of movement were contradictory in different localities and even at the same locality. At Acme suspended objects swung, and coffee was spilled, in a direction a little north of east. The same observation was made during the earthquake of December 20, 1932. At Luning the same direction of movement was ascertained, though objects were thrown from the west wall of the store rather than from the north and south walls as in 1932. At Marietta observers thought the movement was from the southeast. At Mina the movement was reported to be north and south and more regular than those from

[1] Vincent P. Gianella and Eugene Callaghan, "The Earthquake of December 20, 1932, at Cedar Mountain, Nevada, and Its Bearing on the Genesis of Basin Range Structure," *Journal of Geology*, **42**, 1–22, 1934.

Vincent P. Gianella and Eugene Callaghan, "The Cedar Mountain, Nevada, Earthquake of December 20, 1932," *Bulletin of the Seismological Society of America*, **24**, 345–378, 1934.

[2] Harry O. Wood and Frank Neumann, "Modified Mercalli Intensity Scale of 1931," *Bulletin of the Seismological Society of America*, **21**, 277–283, 1931.

the December, 1932, earthquake. In the mountains, as at Silver Dike, the movement was thought to be very rapid but no impression of direction was obtained.

The earthquake produced many of the usual effects including landslides, dust clouds, boulders rolling down slopes, changes in the flow of springs, fissures in alluvium, damage to structures, and fright and nausea among people. Springs along the northwest side of Teel's Marsh were reported to show increased flow and by the middle of April the water supply to the mill at Silver Dike failed. A large landslide on the mountain west of Teel's Marsh was observed by people at Marietta. Smaller rockslides were noted at various places in the Excelsior Mountains. Boulders were rolled down steep slopes almost everywhere in the Excelsior Mountains and in some of the near-by ranges. The writers observed that numerous boulders were rolled down near the foot of the mountains but few in the summit area. This might be due to the more gentle slopes of the summit area, but may indicate a more severe shaking at the margins. Banks of the washes were shaken down in many places as shown in Figure 4 (Plate 25). The walls of a clay pit near Sodaville were reported to have caved. The desert soil was dry at the time except where covered by snow in the summit area of the mountains, and dust clouds, caused by the agitation of the surface of the ground, were noted by all persons interviewed by the writers who had a view over a considerable distance at the time of the strong shock. Observers at widely separated points reported seeing ground waves with a systematically progressing dust cloud in front of them, but this impression was not corroborated by others. A stockman, who was in the mountains south of Whisky Flat, stated that balanced rocks and dead trees vibrated rapidly through a small arc and that the living piñon pines swayed through a large angle.

Earthquake fissures in alluvium were found in three localities, one about one-half mile up the wash above Pepper Spring south of Garfield Flat, another on the northwest side of Teel's Marsh, and the third at the Endowment mine about three miles north of Marietta. At Pepper Spring fissures in the alluvium trend due north along the steep west bank of a wash for a distance of nearly 300 feet. The bank is caved and tumbled down and boulders were displaced even on slight slopes. The downthrown side of the fissures is toward the wash. These features appear to be related to slumping of the alluvium rather than to primary faulting. This particular spot appears to have been shaken with greater violence than near-by areas. At Teel's Marsh the fissures were formed in the nearly flat, soft, wet fill of this inclosed basin. The average trend is north 10° west, and the length nearly 100 feet. A graben at one place is twenty feet wide with a slump hole at the west side two feet deep (Fig. 5, Plate 25). These fissures are believed to be due to shaking of the soft, water-soaked alluvium such as has occurred during other earthquakes.[3] There is no reason to believe that they are related to primary faults. The two seen at the Endowment mine were well within the mountains. One was twenty feet in length and the other about 100 feet and trend north 50° to 60° east. Both were in the bed of the wash about 400 feet beyond the end of the earthquake fault.

Damage to structures was slight considering the intensity of the shock. At Hawthorne new cracks appeared in concrete, and some groceries were tumbled from shelves in stores at Luning and Mina. At Mina a small section fell from a brick wall (Fig. 6, Plate 26), which had been badly cracked during the earthquake of 1932. Two chimneys were reported to have tumbled, and many objects were thrown from shelves in stores and residences. In general, the effects at Mina were not so pronounced as in the previous earthquake. At Candelaria the southeast corner of a stone cabin was thrown out (Fig. 7, Plate 26). The remains of an old brick furnace about two miles south of Garfield Flat were shaken down. At Camp Douglass (Silver Star on map) no damage to mill machinery or mine was reported. At the Silver Dike tungsten mine rolling rocks damaged the pipeline and pumphouse, and concrete in the mill floor was cracked. At Marietta the southeast corner of an adobe brick cabin was thrown out (Fig. 8, Plate 27), but walls of near-by roofless stone buildings remained intact.

This earthquake provided an opportunity to obtain data on the relative perception of shocks on the surface of the ground and underground in the mines. As the principal shock occurred during the noon hour when most of the miners were at the surface, no data on it are available. The miners were all agreed, however, that such shocks as they felt were stronger at the surface than underground. Miners in a tunnel at Marietta reported that they felt obliged to steady themselves during the strong foreshock but were less concerned about the shock and heard less noise than persons at the surface. Miners at Silver Dike scarcely noticed

[3] R. D. Oldham, "Report on the Great Earthquake of June 12th, 1897," *Memoirs of the Geological Survey of India*, **29**, 85–111; State Earthquake Investigation Commission, "The California Earthquake of April 18, 1906"; *Carnegie Institution of Washington Publication No. 87*, **1**, Part 2, pp. 401–402, 1908; Charles Davison, "The Japanese Earthquake of 1923," p. 108, London, Thomas Murby & Co., 1931.

shocks underground that were acutely perceptible to those at the surface. It seems probable that the difference in perception of shocks between the surface and underground may be related to a decrease in amplitude of surface earthquake waves with depth much as the amplitude of water waves decreases from the surface downward.

An interesting observation was made by Mr. W. G. Emminger, mine superintendent at Silver Dike, and the telephone operator at Mina. Both reported that the telephone roared loudly during the principal shock, and the operator observed that the noise lasted several minutes and prevailed longer on grounded lines than on those in which the whole circuit was of metal. The lines were not broken. It is suggested that the agitation of the ground produced earth currents or may have generated static electricity which was transmitted to telephones.

Foreshocks

Several foreshocks were felt outside of the epicentral area. The following data were submitted by Captain H. S. Babbitt, in charge of the United States Naval Ammunition Depot at Hawthorne.[4]

January 29, 7:17 p.m. tremor
30, 11:22 a.m. prolonged tremor (20 sec.)
January 30, 11:27 a.m. tremor

That at 11:22 was strong in the epicentral area and was widely recorded on seismographs. At Marietta it was reported to have rolled rocks and to have been felt by miners underground. It was quite strong at Mina. The foreshock at 7:17 p.m., January 29th, was felt at Silver Dike and was described by Mr. Emminger as a single bump. In reference to foreshocks this earthquake differs from that of December 20, 1932. In the latter earthquake only one foreshock was noted, and that by a single observer.

Aftershocks

Aftershocks were still continuing in April, though declining in intensity and frequency. Many of them were of sufficient violence to roll rocks on steep slopes, and a rock dislodged by an aftershock on February 20th again broke the pipeline at Silver Dike. Those recorded by Captain Babbitt[5] at Hawthorne for the day of the principal shocks and part of the following day are listed below:

[4] Personal communication.

[5] *Ibid.*

January 30,	12:20 p.m. tremor
	12:26 p.m. small, short, but sharp, shock
	12:31 p.m. tremor
	12:37 p.m. tremor
	12:57 p.m. tremor
	3:42 p.m. pronounced tremor
	4:22 p.m. pronounced tremor
	5:52 p.m. pronounced tremor
	7:49 p.m. slight tremor
	7:53 p.m. heavier tremor
	8:27 p.m. tremor
January 30,	9:54 p.m. tremor
January 31,	6:15 a.m. prolonged tremor
	6:27 a.m. pronounced tremor
January 31,	6:29 a.m. slight tremor

At Silver Dike and Marietta aftershocks were reported to have occurred within a few minutes, and sometimes within a few seconds, of each other during the first days after the principal shock. Aftershocks of the earthquake at Cedar Mountain in 1932 may be confused with those originating in the Excelsior Mountains. An aftershock originating at the former place on March 24th was reported to have cracked the dumps at the Simon Mine and to have broken a few windows at Mina. It was perceptible at Silver Dike but passed unnoticed at Marietta.

Earthquake Sounds

Though impressions differed somewhat among observers, it is certain that a roar or deep rumbling accompanied, or preceded, the main shock. The roar was very pronounced at Silver Dike but at some places this sound was confused with the noise caused by rocks rolling down slopes. It was reported that at Marietta a rather high-pitched swishing noise accompanied the strong foreshock. The writers noted rumbles accompanying the aftershocks which they felt while in the Excelsior Mountains, but noted no rumbles in Mina.

Earthquake Fault and Theoretical Considerations

A break in the surface of the ground along the trace of an old fault extends for approximately 4,500 feet across the ridges on the south side of the Excelsior Mountains three and one-quarter miles north-

ɪɢ. 1.—Topographic map showing the Excelsior Mountains and vicinity. The dotted lines indicate traverse
; and the crosses indicate the location of fissures. The earthquake fault occurs in the canyon north-north-
of Marietta. Taken from the Hawthorne quadrangle of the United States Geological Survey.

FIG. 2.—The abrupt southern slope of the Excelsior Mountains at Marietta. Teel's Marsh at the left. This area appears to have been as violently shaken as any part of the epicentral area. A landslide occurred at the time of the earthquake on the mountain at the left beyond Teel's Marsh. The earthquake fault is located in the mountains at the right.

FIG. 3.—Comparatively gentle slopes in the summit area of the eastern part of the Excelsior Mountains. This is in sharp contrast to the steep margins shown in Figure 2. Pilot Mountains in the distance.

FIG. 4.—Gravel bank of wash shaken down during earthquake in canyon in Excelsior Mountains northwest of Marietta near the earthquake fault.

FIG. 5.—Irregular graben fissure in the water-soaked alluvium in Teel's Marsh south of Marietta. The small block has dropped two feet. These fissures are believed to be caused by the agitation of the alluvium rather than to be related to a primary fault. Excelsior Mountains in the distance.

FIG. 8.—The south wall and part of the east wall of this adobe brick cabin at Marietta fell outward during the earthquake. This building was reported to have completely collapsed during an aftershock in May. Walls of near-by roofless stone buildings remained intact.

FIG. 9.—Earthquake scarp five inches high three and one-quarter miles north of Marietta.

FIG. 6.—Section over window of a brick wall in Mina shaken out during the earthquake. The wall was cracked during the earthquake of December 20, 1932.

FIG. 7.—The southeast corner of this stone cabin at Candelaria fell outward during the earthquake.

northwest of Marietta (Fig. 10). The average trend is north 65° east. The old fault is marked by a broad crush zone within metamorphic rocks. The contact of the metamorphic rocks with the volcanic rocks lies a short distance to the north but does not reach the fault. The fault trace is deeply eroded and is followed by gulches through part of its length as shown in Figure 10. There is no scarp or other indication of relative movement prior to the earthquake. The earthquake scarp has a maximum height of five inches (Fig. 9, Plate 27), and the fissures are open as much as three inches. The displacement is everywhere toward the northwest, that is, the summit area of the range has dropped with respect to the south side. The dip, as shown by the curve up the gulches, is approximately seventy-three degrees to the north-northwest. The fault is not a continuous break throughout, but in many places, particularly toward the ends, it consists of open fissures *en echelon* which trend approximately ten degrees more toward the north than the direction of the fault.

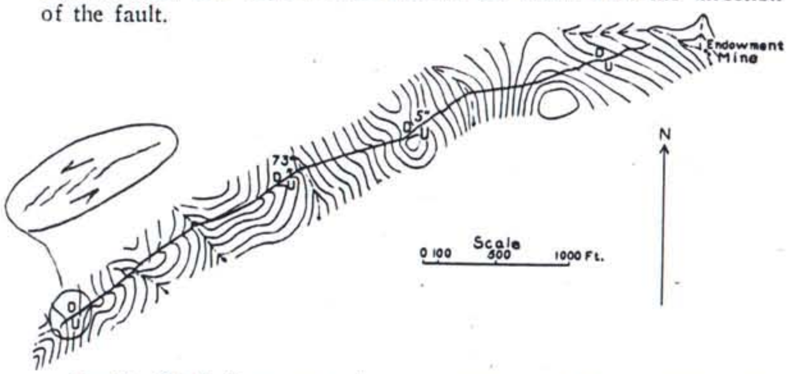

FIG. 10.—Sketch from pace and compass traverse showing the course of the fault formed at the time of the earthquake. The contours have only sketch value, but they serve to show how the fault follows gulches which occur on the trace of the old fault. Note how the fault turns northward in the transverse gulches indicating a steep dip to the north (73°).

The fact that the earthquake fault follows the old fault zone with rock outcrops on both sides, and the fact that the displacement is down on the uphill, or north, side indicates the primary nature of the earthquake fault or rift. The pattern of the *en echelon* fissures indicates a slight relative horizontal movement or component of movement of the north side toward the southwest with respect to the south side.

It appears that movement on this fault was the cause of the earthquake, though it does not at first seem that the amount of movement recorded at the surface should have generated such a strong shock. However, many earthquakes occur without the formation of fault scarps, so that it appears to be within the realm of possibility that the fault movement was the cause of the earthquake.

This earthquake differs from those previously described in the Great Basin in that the fault occurs within the mountain range rather than in the valley area[6] or along the base of the range.[7] Consequently, it represents a third type of earthquake fault classified according to locality within the Great Basin and indicates that movements are taking place within the Basin ranges as well as along the margins and within the valleys.

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Field work was carried on by Mr. Callaghan during February 18–21 and during June 11, 1934. Mr. Gianella spent March 24–26 in furthering the investigation. The inhabitants of the region were uniformly willing to give information. As in 1932, Captain H. S. Babbitt and Mr. L. B. Spencer were particularly helpful. Mr. W. G. Emminger supplied valuable information on the location of the earthquake fault. Mr. Whiteaker of Acme assisted for a day, and Mr. Thomas P. Thayer assisted in the mapping of the earthquake fault. The writers are indebted to Mr. H. G. Ferguson of the United States Geological Survey for information on the geology of the Excelsior Mountains and for critical reading of the manuscript. Mr. Callaghan is particularly grateful to The Geological Society of America for the fund covering the expenses in the field and to the United States Geological Survey for permission to make the investigation.

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[6] W. H. Hobbs, "The Earthquake of 1872 in the Owens Valley, California," *Beiträge zur Geophysik*, **10**, 352–385, 1910.

Adolph Knopf, "A Geological Reconnaissance of the Inyo Range and the Eastern Slope of the Southern Sierra Nevada, California," *United States Geological Survey Professional Paper* 110, pp. 80–81, 1918.

Vincent P. Gianella and Eugene Callaghan, "The Earthquake of December 20, 1932, at Cedar Mountain, Nevada, and Its Bearing on the Genesis of Basin Range Structure," *Journal of Geology*, **42**, 1–22, 1934.

Vincent P. Gianella and Eugene Callaghan, "The Cedar Mountain, Nevada, Earthquake of December 20, 1932," *Bulletin of the Seismological Society of America*, **24**, 345–378, 1934.

[7] J. C. Jones, "The Pleasant Valley, Nevada, Earthquake of October 2, 1915," *Bulletin of the Seismological Society of America*, **5**, 190–205, 1915.