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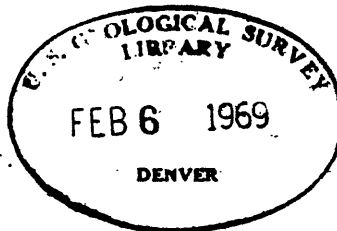
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UNITED STATES DEPARTMENT OF THE INTERIOR  
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SEISMIC ACTIVITY IN THE SUNNYSIDE MINING  
DISTRICT, UTAH, DURING 1967

By

Barton K. Barnes, C. Richard Dunrud, and  
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# SEISMIC ACTIVITY IN THE SUNNYSIDE MINING DISTRICT, UTAH, DURING 1967

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## ABSTRACT

A seismic monitoring network near Sunnyside, Utah, consisting of a triangular array of seismometer stations that encompasses most of the mine workings in the district, recorded over 50,000 local earth tremors during 1967. About 540 of the tremors were of sufficient magnitude to be accurately located. Most of these were located within 2-3 miles of mine workings and were also near known or suspected faults.

The district-wide seismic activity generally consisted of two different patterns--a periodic increase in the daily number of tremors at weekly intervals, and also a less regular and longer term increase and decrease of seismic activity that occurred over a period of weeks or even months. The shorter and more regular pattern can be correlated with the mine work week and seems to result from mining. The longer term activity, however, does not correlate with known mining causes and therefore seems to be caused by natural stresses.

## INTRODUCTION

The seismic monitoring network near Sunnyside in eastern Carbon and Emery Counties, Utah (figs. 3, 4, 5, 6), is an important research tool for use in studying the influence of geologic features and mining practices on coal mine bumps, a common hazard to lives and property in the district (Osterwald and Dunrud, 1966; Osterwald, Dunrud, and Maberry, 1967a, b). During 1967, an estimated 50,000 tremors (figs. 1, 2) were recorded, of which about 540 (tables 1, 2) were of sufficient magnitude to be received by at least three of the stations in the network enabling the hypocenters to be accurately located (figs. 3, 4, 5, 6).

## SEISMIC MONITORING NETWORK

The seismic network includes three primary seismometer stations (figs. 3, 4, 5, 6) arranged in a triangular array that encompasses the mining district (Dunrud and Osterwald, 1965; Maberry, 1966; Osterwald and Dunrud, 1966). Supplemental stations are located in Horse Canyon and Pasture Canyon (figs. 3, 4, 5, 6). Each station consists of a Willmore-type vertical component seismometer and a battery-powered preamplifier that are housed in a reinforced concrete structure anchored to bedrock. Outlying stations are linked by U.S. Army field telephone wires to a central recording station in Pasture Canyon.

Signals are recorded simultaneously on chart paper and on magnetic tape at the central station. Recording is continuous except for chart-paper and magnetic-tape changes, which last for about 30 minutes once every 24 hours. The network is operated and maintained by Hernandez, who also makes preliminary interpretations of the network seismograms before they are mailed to the project geologists. Most equipment in the network was designed or modified for its specific use by John B. Bennetti, Jr., who also makes periodic inspections and calibrations during its operation. Magnetic tapes are played back in a mobile laboratory van by John O. Maberry or Jerome Hernandez, using a light-beam direct-writing oscillograph.

Hypocenters of recorded tremors are located accurately (diameter of sphere of confidence is about 2,000 feet for the first three-quarters of 1967 and about 1,000 feet for the last quarter) using multiple traveltimes overlay curves. Ground motion is accurately recorded on 14-channel, 1-inch FM analog magnetic tape. Unfiltered frequency response of the tape recording system is flat from 0 to about 200 cycles per second. Because of the geometry of the monitoring network, hypocenters of tremors in some parts of the Sunnyside No. 2 mine and the Columbia mine cannot be as accurately located as those occurring in the other parts of the district.

#### SEISMIC ACTIVITY

Most of the tremor epicenters recorded in 1967 were within or adjacent to the map positions of the mines (figs. 3, 4, 5, 6); nearly all were closer than 16,000 feet to the mine boundaries and less than 10,000 feet below the mine level.

The daily numbers of tremors recorded by the Bear Canyon and Horse Canyon stations are shown on figures 1 and 2 respectively. In general, there are intervals of about 7 days between peaks of high activity. This cyclic pattern of seismic activity corresponds closely to the mining work weeks (figs. 1, 2), in that the number of tremors per day is high for 4-5 days during the days the mines are worked and decreases during the days the mines are idle. For example, the daily number of recorded tremors decreased significantly in the northern part of the district (fig. 1) during the miners' vacation during the last few days of June and most of July.

The same pattern may exist in the southern part of the district (fig. 2), although in that area the lowest number of tremors per day occurred during August--a minimum that was part of a general decrease that began during May--suggesting that the short-period cycles may be superimposed on long-period cycles. The patterns of these long-period cycles of increasing and decreasing numbers of tremors per day in the northern and southern parts of the district do not correspond to those for the first 6 months of 1967 (figs. 1, 2). The patterns do correspond in general, however, to those from July through December (figs. 1, 2).

## INFLUENCE OF GEOLOGIC STRUCTURE AND MINING

### ON LOCATIONS OF TREMOR SOURCES AND BUMPS

Most tremors occur around actively mined areas, or in areas that are known to be subjected to high concentrations of stress because of the size or geometry of the mine workings. Many tremors, however, occur northeast of the Geneva mine, where the steeply dipping, north-northwest-trending Sunnyside fault zone intersects the more gently dipping east-northeast-trending faults of the Geneva mine area (figs. 3, 4, 5, 6).

As shown on the maps (figs. 3, 4, 5, 6), tremors in the southern part of the mining district generally occur at greater depths, are more concentrated and frequent, and are of greater magnitude than those that occur in the northern part of the district. Focal depths of tremors occurring in the Geneva mine area, in the southern part, commonly range from 2,000 feet above sea level to 2,000 feet below sea level, whereas depths in the Columbia and Sunnyside mine areas, in the northern part, commonly range from 2,000 to 6,000 feet above sea level.

Much of the intense seismic activity at greater depth in the southern part of the district may result from one or a combination of the following:

1. The Sunnyside fault zone transects a graben at the north edge of the Geneva mine (figs. 3, 4, 5, 6);
2. Fault attitudes in the Geneva mine area are less steep and vary considerably more than those in the northern part;
3. A subsurface fault dips northeastward beneath the southern part of the mining district (figs. 3, 4, 5, 6).

Potentially hazardous bumps are more common in the mines during periods of increased seismic activity (large numbers of tremors per day) (Osterwald and Dunrud, 1966, p. 104). They occur within a few hours to a few days after an increase in the daily number of tremors. The period between seismic buildup and bump occurrence commonly is shorter in the southern part of the district than in the northern part, and at times is only a few hours in length. Bumps commonly occur in mines near the plotted map positions of earth tremors, but many tremors that are large enough to accurately locate are thousands of feet below the mine level, particularly in the Geneva mine area. Close daily observation of the numbers of tremors per day (figs. 1, 2) and of the location of the earth tremors (figs. 3, 4, 5, 6) may result in the forecasting of areas that will become susceptible to bumps.

### DESCRIPTION OF SEISMIC ACTIVITY BY QUARTER

Some specific observations of seismic activity patterns and their spatial relationship to faults and to mining areas (figs. 3, 4, 5, 6) by calendar quarter follow:

### First quarter seismic activity (fig. 3):

Sunnyside Nos. 1 and 3 mines: Epicenters of most tremors were scattered north and east of active mining areas, but the foci were near the mining level--about 4,000-6,000 feet above sea level.

Sunnyside No. 2 mine: Tremors occurred in actively mined areas and along faults; most foci were approximately at the mining level. Few tremors occurred in this mine during the next quarter, when no mining was done.

Columbia mine: Foci were distributed throughout the mine, but locally were concentrated along east-northeast- and east-west-trending faults and in an abandoned mining area near the east end of the 8th east slope (8-E, fig. 3); most were near the mining level.

Geneva mine: Numerous tremors were scattered northeast of the mine; foci were 2,000 feet below sea level to 6,000 feet above sea level. Other tremors were concentrated along west-northwest- and east-northeast-trending faults, particularly at fault intersections, and at various depths to as much as 2,000 feet below sea level, near 2d level north (2-N on fig. 3). A few tremors occurred at scattered locations in the southern part of the mine.

### Second quarter seismic activity (fig. 4):

Sunnyside Nos. 1 and 3 mines: A few tremors of low magnitude, most of whose foci were between 2,000 and 4,000 feet above sea level, occurred north of the mines.

Sunnyside No. 2 mine: Tremors occurred throughout the central and southern parts of the mine; most of the foci were between 4,000 and 6,000 feet above sea level in the eastern part of the mine and between 0 to 4,000 feet above sea level elsewhere. Mining ceased during this quarter.

Columbia mine: Many tremors whose foci were between 0 and 6,000 feet above sea level occurred along the barrier pillar between the Sunnyside No. 2 and Columbia mines. Other tremors whose foci were between 2,000 feet below sea level to 2,000 feet above sea level occurred near Patmos Head. Many tremor foci were along the junction of the Sunnyside fault zone with an east-northeast-trending fault in the southern part of the mine. Some tremors occurred locally along faults in the southwestern part of the mine.

Geneva mine: Numerous tremors concentrated northeast of the mine and probably were controlled in general by the intersection between the Sunnyside fault zone and the east-northeast- to east-west-trending graben. Foci of these tremors were 2,000 feet below sea level to 6,000 feet above sea level. Some tremors were localized east of the mine near a west-northwest-trending fault; most foci of these tremors were 2,000 feet below sea level. A few tremors occurred near east-west-trending faults in the southern part of the mine; foci were between 4,000 feet below sea level to 2,000 feet above sea level.

### Third quarter seismic activity (fig. 5):

Very few tremors were recorded during this quarter, but small concentrations did occur near faults in the Columbia, Geneva, and Sunnyside No. 2 mines. Mining had ceased in the Columbia mine on May 30.

### Fourth quarter seismic activity (fig. 6):

Sunnyside No. 1 mine: A few low-magnitude tremors occurred throughout the mine. Some were localized near active mining areas in 12 Left and 13 Left entries (12-L, 13-L, fig. 5); but foci were about 2,000 to 4,000 feet below the mine level.

Sunnyside No. 3 mine: Most tremors were widely distributed and of low magnitude, but one large tremor occurred about 4,000 feet below an active mining area.

Columbia mine: Several tremors occurred between east-trending faults in the southern part of the mine.

Geneva mine: Three tremors occurred near east-northeast- and west-northwest-trending faults that partially bound an active mining area (coordinate 13,000 S., 0). Several tremors occurred close to but north of an active mining section in the southern part of the mine, along a barrier pillar. Foci of these tremors were beneath old mine workings and on faults adjacent to 1st level south, and ranged from 4,000 feet above sea level to 2,000 feet below sea level.

### CONCLUSIONS

Of the 50,000 or more earth tremors recorded by the Sunnyside seismic network in 1967, nearly all were located relatively close to mine areas. Although the smaller magnitude tremors could not be accurately located, they were only recorded by the seismometer stations nearest to the mine workings. This implies that, although natural stresses influence the size and number of earth tremors in a given period, mining initiates or triggers most of the earth tremors.

Many of the larger earth tremors plot near faults or fault intersections. This suggests that the stresses induced during mining are commonly relieved or readjusted along these discontinuities. Particularly severe and large-scale bumps in the mine are more common during or shortly after a concentration of large-magnitude earth tremors in a relatively small area and often occur near the mapped position of these severe concentrations of seismic activity. This suggests that the tremors are in response to stress relief and readjustment along or near the faults and that the bumps are manifested by these readjustments.

#### ACKNOWLEDGMENTS

Generous assistance, in the form of mining data, maps of underground workings, access to their respective properties, and frequent discussion of mutual problems, was given continually by officials of Kaiser Steel Corp. and United States Steel Corp. We thank them for their help and cooperation.

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- \_\_\_\_\_, 1967b, Preliminary structural and lithologic map of the Sunnyside No. 2 mine and Columbia Mine area, Carbon and Emery Counties, Utah, showing coal outcrop, structure contours and surface faults: U.S. Geol. Survey Misc. Inv. Map I-582, Sheet 2.

Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
First quarter (Jan., Feb., and March)				
(MST)				
Jan. 2	11:26 a.m.	1.5	41,700 N., 57,800 E.	7
3	7:12 a.m.	1.8	40,200 N., 57,100 E.	1
3	7:59 p.m.	2.1	60,700 N., 58,600 E.	2
5	2:00 a.m.	1.8	40,600 N., 59,600 E.	7
6	1:54 p.m.	1.8	38,600 N., 54,900 E.	7
10	3:53 p.m.	1.9	38,900 N., 57,200 E.	7
11	2:03 a.m.	1.5	41,200 N., 57,000 E.	6
12	9:45 a.m.	1.8	68,600 N., 47,500 E.	SL
12	1:36 p.m.	1.2	40,400 N., 56,600 E.	6
13	5:22 a.m.	1.6	72,000 N., 52,700 E.	6
13	10:22 a.m.	1.0	69,100 N., 51,600 E.	6
14	2:48 p.m.	1.6	57,800 N., 59,500 E.	6
15	10:34 p.m.	1.1	38,800 N., 56,900 E.	7
16	12:24 a.m.	1.6	38,000 N., 57,000 E.	7
18	7:09 a.m.	2.2	38,900 N., 57,200 E.	7
18	9:25 a.m.	2.2	33,600 N., 60,200 E.	7
19	4:13 a.m.	2.1	39,700 N., 58,100 E.	7
21	5:10 p.m.	1.9	70,600 N., 47,600 E.	6
22	1:50 p.m.	2.7	40,300 N., 55,500 E.	7
23	2:06 a.m.	1.9	40,100 N., 58,800 E.	7
24	12:38 p.m.	2.3	40,500 N., 54,400 E.	7
25	3:40 a.m.	2.3	39,200 N., 57,000 E.	7
29	10:08 p.m.	1.2	66,200 N., 43,200 E.	7
Feb. 4	9:30 a.m.	2.3	68,700 N., 5,000 E.	SL
7	7:21 p.m.	2.2	39,700 N., 56,200 E.	7
8	2:05 p.m.	1.7	40,900 N., 57,100 E.	7
9	9:12 a.m.	2.1	60,600 N., 53,700 E.	6
12	12:29 a.m.	2.0	41,200 N., 54,500 E.	7
12	3:56 p.m.	1.9	59,300 N., 53,900 E.	7
13	1:43 p.m.	1.6	64,400 N., 59,800 E.	7



Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
First quarter (Jan., Feb., and March)				
(MST)				
Feb. 14	10:29 a.m.	1.7	67,800 N., 41,800 E.	7
14	12:38 p.m.	1.2	68,500 N., 57,600 E.	7
14	2:24 p.m.	2.2	40,400 N., 56,400 E.	7
16	7:02 p.m.	2.0	59,200 N., 52,600 E.	7
17	11:41 p.m.	1.5	70,600 N., 47,000 E.	7
20	9:45 a.m.	1.6	39,500 N., 57,200 E.	7
20	2:03 p.m.	2.0	42,500 N., 56,800 E.	7
20	6:54 p.m.	1.7	76,600 N., 56,800 E.	7
22	2:12 a.m.	2.0	39,300 N., 58,900 E.	7
22	8:56 a.m.	2.0	64,400 N., 50,600 E.	7
March 4	9:38 a.m.	1.3	41,700 N., 53,900 E.	7
7	2:02 a.m.	1.3	54,500 N., 53,600 E.	7
8	9:18 p.m.	1.2	33,200 N., 62,100 E.	7
9	8:21 a.m.	0.8	63,800 N., 50,800 E.	3
9	8:39 a.m.	1.3	67,200 N., 42,700 E.	7
10	2:12 p.m.	2.0	40,300 N., 60,100 E.	7
11	3:59 a.m.	2.2	39,200 N., 60,200 E.	7
13	8:16 a.m.	1.7	65,000 N., 67,400 E.	7
19	1:16 a.m.	2.2	51,400 N., 53,400 E.	7
21	6:18 a.m.	2.8	68,800 N., 47,000 E.	3
22	9:33 a.m.	1.2	38,600 N., 65,400 E.	7
24	5:29 a.m.	2.1	61,100 N., 44,800 E.	7
25	7:42 a.m.	1.7	51,400 N., 57,400 E.	7
26	3:56 a.m.	1.9	34,300 N., 53,600 E.	7
27	8:42 a.m.	2.1	62,500 N., 58,700 E.	7

Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1/</sub>
Second quarter (April, May, June)				
(MST)				
April 7	7:43 p.m.	2.8	34,400 N., 55,900 E.	1
11	3:13 a.m.	1.2	65,300 N., 50,000 E.	7
11	9:15 p.m.	1.0	75,500 N., 51,900 E.	5
13	4:28 p.m.	1.5	38,300 N., 59,800 E.	3
16	8:51 a.m.	2.4	38,800 N., 57,800 E.	7
16	1:13 p.m.	1.6	32,900 N., 61,100 E.	2
18	1:31 p.m.	2.3	38,200 N., 57,400 E.	7
18	10:44 p.m.	1.2	22,400 N., 50,800 E.	7
19	10:13 p.m.	1.5	70,400 N., 45,600 E.	7
21	1:37 a.m.	1.7	39,200 N., 61,800 E.	1
21	7:41 a.m.	1.6	38,900 N., 62,300 E.	1
23	0:53 a.m.	2.1	38,700 N., 63,000 E.	7
27	6:41 a.m.	2.2	37,700 N., 60,400 E.	1
27	10:10 a.m.	1.9	36,300 N., 56,200 E.	1
(MDT)				
May 1	2:33 p.m.	1.6	37,100 N., 56,600 E.	1
4	1:47 a.m.	1.9	58,200 N., 52,000 E.	7
4	6:16 a.m.	2.3	35,200 N., 56,300 E.	7
7	6:44 p.m.	1.8	51,900 N., 46,300 E.	7
9	2:48 a.m.	1.8	72,000 N., 61,300 E.	3
10	8:07 p.m.	1.6	79,900 N., 55,400 E.	7
10	11:43 p.m.	2.0	37,200 N., 59,500 E.	1
16	3:40 a.m.	2.0	66,300 N., 44,000 E.	7
17	8:11 a.m.	1.9	71,200 N., 52,900 E.	3
17	1:39 p.m.	1.9	63,000 N., 51,300 E.	3
17	6:55 p.m.	1.7	57,600 N., 48,800 E.	7
18	2:47 a.m.	1.7	74,600 N., 49,100 E.	3
22	12:26 p.m.	1.5	40,800 N., 55,700 E.	SL
26	3:43 p.m.	1.8	40,200 N., 59,800 E.	1
26	4:01 p.m.	2.3	66,000 N., 59,500 E.	3

Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
Second quarter (April, May, June)				
(MDT)				
June 1	5:46 a.m.	1.3	66,000 N., 46,700 E.	7
2	6:51 p.m.	1.9	33,200 N., 56,800 E.	7
8	12:12 p.m.	1.9	39,400 N., 56,300 E.	7
9	5:31 a.m.	1.9	36,900 N., 54,600 E.	7
11	6:11 p.m.	2.0	38,800 N., 54,300 E.	7
12	12:12 a.m.	1.6	40,700 N., 53,200 E.	7
12	7:15 a.m.	1.9	39,300 N., 52,000 E.	7
12	5:50 p.m.	2.0	81,100 N., 50,000 E.	7
12	7:26 p.m.	2.2	78,900 N., 51,800 E.	3
13	6:30 a.m.	1.7	39,300 N., 52,100 E.	7
13	8:29 p.m.	1.6	37,700 N., 59,200 E.	1
14	6:43 a.m.	1.5	39,700 N., 55,300 E.	7
14	4:18 p.m.	1.8	39,800 N., 60,400 E.	7
16	1:05 p.m.	2.1	40,200 N., 56,800 E.	7
16	8:40 p.m.	2.0	37,900 N., 56,200 E.	7
23	12:23 a.m.	2.4	59,400 N., 46,600 E.	4
23	3:12 a.m.	2.0	65,700 N., 52,800 E.	SL
24	6:28 a.m.	1.7	37,200 N., 58,000 E.	7
Third quarter (Aug., Sept., no data for July)				
Aug. 15	4:40 a.m.	2.2	70,800 N., 60,400 E.	3
22	7:23 p.m.	2.2	59,100 N., 49,700 E.	7
Sept. 2	12:39 p.m.	2.5	61,600 N., 59,100 E.	2/4
2	1:18 p.m.	2.1	66,400 N., 49,600 E.	2/SL
5	8:27 a.m.	1.7	37,800 N., 55,100 E.	7

Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1/</sub>
Third quarter (Aug., Sept., no data for July)				
(MDT)				
Sept. 7	2:17 p.m.	2.2	40,500 N., 58,900 E.	7
16	1:56 p.m.	1.4	68,600 N., 55,200 E.	3
20	11:33 a.m.	1.8	59,800 N., 57,200 E.	2
20	12:03 p.m.	1.2	38,500 N., 55,600 E.	7
26	2:40 p.m.	1.7	38,500 N., 54,800 E.	7
Fourth quarter (Oct., Nov., and Dec.)				
Oct. 10	9:24 a.m.	1.8	66,200 N., 50,700 E.	3
10	10:40 p.m.	2.1	52,700 N., 61,400 E.	1
11	4:08 p.m.	2.3	38,300 N., 54,800 E.	6
11	9:42 p.m.	2.1	38,400 N., 54,600 E.	6
12	5:48 p.m.	2.5	75,300 N., 54,000 E.	1
12	11:15 p.m.	1.5	48,200 N., 54,100 E.	4
16	10:21 p.m.	2.3	42,700 N., 51,500 E.	6
18	4:11 a.m.	1.7	38,400 N., 54,500 E.	6
18	9:14 p.m.	1.5	35,800 N., 49,200 E.	6
18	3:05 p.m.	1.5	36,700 N., 50,500 E.	6
19	7:02 p.m.	1.7	48,400 N., 51,800 E.	6
20	2:03 a.m.	1.6	61,200 N., 47,400 E.	6
21	12:37 p.m.	1.3	42,200 N., 43,800 E.	6
28	2:14 p.m.	2.3	38,200 N., 51,800 E.	<u>2/6</u>
(MST)				
Nov. 29	1:31 p.m.	1.8	36,900 N., 54,400 E.	6
1	2:58 a.m.	1.9	50,300 N., 49,400 E.	3
1	7:34 a.m.	2.1	35,400 N., 53,800 E.	7
1	8:14 a.m.	1.9	74,000 N., 51,400 E.	5
1	9:29 p.m.	1.8	68,600 N., 56,400 E.	3

Table 1.--Location of earth tremors near the Sunnyside No. 1, 2, and 3  
mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
Fourth quarter (Oct., Nov., and Dec.)				
(MST)				
Nov. 4	12:08 a.m.	2.3	36,700 N., 56,100 E.	7
8	1:29 p.m.	1.2	61,300 N., 51,500 E.	3
9	12:56 p.m.	1.6	37,400 N., 56,300 E.	7
9	2:44 p.m.	1.8	36,300 N., 56,000 E.	7
13	8:40 p.m.	1.9	37,400 N., 57,300 E.	7
13	11:57 p.m.	2.1	37,400 N., 55,500 E.	<u>2/7</u>
15	5:10 p.m.	2.8	49,100 N., 58,000 E.	4
16	4:09 a.m.	1.0	49,800 N., 49,300 E.	3
22	10:15 a.m.	1.2	70,000 N., 56,000 E.	7
26	10:00 a.m.	2.3	41,200 N., 57,500 E.	<u>2/3</u>
27	8:17 a.m.	2.2	56,000 N., 48,700 E.	<u>2/4</u>
27	10:32 p.m.	2.6	62,200 N., 46,000 E.	<u>2/6</u>
Dec. 5	2:19 p.m.	1.4	62,200 N., 47,600 E.	<u>2/7</u>
5	1:24 p.m.	2.1	58,900 N., 48,200 E.	<u>2/7</u>
9	12:19 p.m.	1.4	36,400 N., 52,000 E.	7
14	3:15 p.m.	2.2	60,700 N., 49,200 E.	<u>2/5</u>
14	3:28 p.m.	2.1	60,400 N., 49,300 E.	<u>2/4</u>
16	8:17 a.m.	2.0	10,500 N., 49,400 E.	1
20	3:05 a.m.	1.7	33,800 N., 55,600 E.	7

<sup>1/</sup>SL, sea level (focus datum).

<sup>2/</sup>Magnetic tape playback solution.

Table 2.- Location of earth tremors near the Columbia  
and Geneva Mines during 1967

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
First quarter (Jan., Feb., and March)				
(MST)				
Jan. 1	1:32 a.m.	1.8	12,500 S., 6,800 E.	6
3	1:35 p.m.	1.8	17,500 S., 7,900 E.	-2
3	7:13 p.m.	2.0	19,600 S., 3,200 E.	1
3	7:16 p.m.	2.0	31,600 S., 11,000 E.	1
4	12:53 a.m.	1.9	15,800 S., 6,400 E.	-2
4	1:04 a.m.	2.1	15,100 S., 5,400 E.	SL
4	1:09 a.m.	1.4	15,200 S., 200 E.	SL
4	1:10 a.m.	1.5	24,900 S., 8,000 E.	1
4	1:12 a.m.	1.6	17,900 S., 2,300 E.	SL
4	1:13 a.m.	1.8	17,200 S., 5,300 E.	-3
4	1:21 a.m.	1.8	17,800 S., 4,300 E.	-1
4	6:49 a.m.	1.9	20,900 S., 6,400 E.	1
4	6:51 a.m.	2.1	15,700 S., 200 W.	1
4	7:00 a.m.	0.8	24,800 S., 6,500 E.	1
4	3:47 p.m.	2.4	44,000 S., 1,800 W.	-1
5	6:34 a.m.	2.8	12,800 S., 15,200 E.	-1
5	6:42 a.m.	2.4	16,600 S., 4,400 E.	1
5	8:16 a.m.	2.5	18,500 S., 5,300 E.	SL
5	8:51 a.m.	2.4	13,900 S., 5,500 E.	-1
5	8:59 a.m.	2.0	20,200 S., 7,200 E.	1
5	5:56 p.m.	2.0	19,900 S., 8,900 E.	-1
5	8:58 p.m.	1.8	16,800 S., 4,500 E.	-4
5	10:51 p.m.	2.4	15,600 S., 4,400 E.	-2
6	12:38 a.m.	1.9	25,800 S., 7,400 E.	SL
6	4:33 a.m.	1.3	20,000 S., 4,800 E.	-1
6	9:06 p.m.	0.9	16,800 S., 6,800 E.	-1
7	9:13 p.m.	1.7	25,300 S., 800 E.	3
12	11:53 a.m.	1.1	14,400 S., 9,700 E.	3
13	4:13 a.m.	1.6	15,400 S., 13,200 E.	3
16	3:48 a.m.	1.7	17,700 S., 9,800 E.	3

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
First quarter (Jan., Feb., and March)				
(MST)				
Jan. 16	11:38 a.m.	2.3	15,300 S., 10,600 E.	SL
18	6:17 a.m.	2.2	19,700 S., 6,300 E.	SL
19	2:35 a.m.	1.5	21,400 S., 4,400 E.	1
22	3:11 a.m.	2.2	1,800 S., 6,300 E.	7
22	2:55 p.m.	1.8	16,600 S., 3,600 E.	1
24	0:09 a.m.	2.1	6,200 S., 5,400 E.	7
24	8:11 a.m.	1.6	10,700 S., 3,400 E.	7
24	8:15 a.m.	1.9	8,000 S., 2,300 E.	7
25	9:54 a.m.	1.5	21,900 S., 4,300 E.	1
25	11:48 a.m.	2.1	21,700 S., 5,700 E.	SL
25	8:17 p.m.	1.9	17,000 S., 3,100 E.	-1
26	7:03 a.m.	2.1	15,400 S., 3,600 E.	-1
26	3:03 p.m.	2.2	16,000 S., 1,000 E.	SL
26	9:25 p.m.	1.7	30,400 S., 6,500 E.	7
26	9:51 p.m.	1.8	18,900 S., 4,200 E.	-1
27	4:14 a.m.	1.6	20,000 S., 6,000 E.	SL
27	1:37 p.m.	2.1	15,500 S., 3,600 E.	1
27	2:58 p.m.	1.7	12,600 S., 1,300 E.	7
27	7:02 p.m.	2.1	20,500 S., 4,200 E.	SL
27	9:10 p.m.	2.0	20,200 S., 3,100 E.	SL
29	3:04 p.m.	1.2	23,100 S., 6,000 E.	1
29	9:53 p.m.	1.4	14,100 S., 4,000 E.	-1
31	5:40 p.m.	2.1	18,800 S., 5,000 E.	SL
Feb. 1	12:31 p.m.	1.6	600 S., 3,900 E.	7
2	11:26 a.m.	1.7	22,200 S., 1,700 E.	1
2	12:12 p.m.	2.0	12,200 S., 4,000 E.	1
2	2:32 p.m.	1.7	15,000 S., 2,200 E.	SL
3	4:37 p.m.	1.4	8,700 S., 1,400 W.	1
3	6:06 p.m.	2.0	14,700 S., 3,100 E.	SL
4	12:33 p.m.	1.8	1,800 S., 5,600 E.	7

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet		Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
First quarter (Jan., Feb., and March)					
(MST)					
Feb.	5	3:07 a.m.	2.8	15,100 S., 2,200 E.	SL
	5	3:32 a.m.	1.9	15,900 S., 700 E.	-1
	5	3:06 p.m.	1.8	18,800 S., 5,500 E.	SL
	5	4:10 p.m.	1.8	21,300 S., 500 E.	1
	5	7:35 p.m.	2.3	18,200 S., 2,500 E.	1
	5	10:00 p.m.	1.9	16,600 S., 2,500 E.	3
	5	11:29 p.m.	1.9	22,200 S., 1,300 E.	1
	6	3:45 a.m.	1.8	13,000 S., 600 E.	7
	7	2:23 a.m.	2.0	1,100 S., 2,400 E.	7
	7	7:01 a.m.	1.8	4,400 S., 700 E.	7
	7	5:39 p.m.	1.9	17,500 S., 2,500 E.	-1
	7	9:52 p.m.	1.8	5,800 S., 2,500 E.	7
	9	5:50 p.m.	1.9	16,100 S., 4,300 E.	1
	10	10:54 a.m.	1.6	14,700 S., 900 E.	1
	10	5:53 p.m.	1.9	6,200 S., 2,500 E.	7
	10	9:45 p.m.	1.9	15,200 S., 3,400 E.	1
	11	6:40 p.m.	2.4	8,500 S., 700 W.	3
	12	7:24 p.m.	2.1	18,600 S., 6,200 E.	1
	12	7:29 p.m.	1.6	13,400 S., 4,100 E.	-1
	13	4:54 p.m.	2.1	14,200 S., 6,900 E.	-1
	13	8:44 p.m.	1.8	7,400 S., 2,200 E.	7
	15	8:02 a.m.	2.6	23,300 S., 2,000 E.	1
	15	9:11 a.m.	1.6	9,600 S., 900 E.	3
	15	10:23 a.m.	2.5	12,200 S., 4,100 E.	SL
	15	6:43 p.m.	2.2	1,000 S., 4,000 E.	7
	16	9:05 p.m.	2.2	3,000 S., 1,200 E.	7
	16	10:24 p.m.	2.3	5,800 S., 2,600 E.	7
	17	1:59 a.m.	1.2	5,800 S., 4,000 E.	7
	17	7:32 p.m.	2.2	8,100 S., 700 E.	7
	17	8:13 p.m.	2.2	25,300 S., 4,000 E.	7



Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
First quarter (Jan., Feb., and March)				
(MST)				
Feb. 19	12:45 a.m.	1.3	8,200 S., 1,000 E.	7
20	2:03 p.m.	1.8	15,200 S., 4,300 E.	7
20	6:44 p.m.	2.4	8,800 S., 1,500 E.	7
22	4:40 a.m.	2.4	5,300 S., 2,300 E.	7
22	1:53 p.m.	2.4	400 S., 5,300 E.	7
28	12:09 a.m.	1.3	12,400 S., 800 E.	2
28	12:16 a.m.	1.2	33,200 S., 10,900 E.	7
28	1:30 a.m.	2.5	4,900 S., 3,600 E.	7
28	10:10 a.m.	1.2	33,600 S., 9,200 E.	7
28	7:26 p.m.	1.1	24,000 S., 8,700 E.	SL
March 1	3:43 a.m.	1.8	5,400 S., 2,700 E.	7
1	9:54 a.m.	1.6	15,100 S., 5,500 E.	1
1	6:40 p.m.	1.5	16,800 S., 1,100 E.	SL
1	6:52 p.m.	1.5	26,400 S., 5,800 E.	1
1	7:23 p.m.	2.0	14,700 S., 3,300 E.	1
2	4:32 p.m.	1.4	14,700 S., 1,300 E.	1
3	6:58 a.m.	2.0	9,300 S., 9,700 E.	7
3	12:10 p.m.	2.9	9,000 S., 11,000 E.	7
3	12:13 p.m.	1.7	5,900 S., 2,300 E.	7
3	3:29 p.m.	2.9	9,300 S., 9,800 E.	7
3	3:33 p.m.	1.9	5,200 S., 4,200 E.	7
3	3:47 p.m.	2.4	12,800 S., 9,700 E.	1
4	2:51 a.m.	1.2	7,000 S., 2,200 E.	7
4	9:25 a.m.	1.7	8,000 S., 3,100 E.	7
6	3:52 p.m.	1.5	7,600 S., 1,900 E.	7
7	6:38 a.m.	2.0	12,300 S., 5,500 E.	7
7	8:05 p.m.	1.3	21,400 S., 3,400 E.	1
8	1:11 a.m.	1.3	22,200 S., 5,700 E.	1
8	10:16 p.m.	1.7	6,600 S., 4,100 E.	7
9	10:04 p.m.	1.0	7,600 S., 8,500 E.	7

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
First quarter (Jan., Feb., and March)				
(MST)				
March 10	6:56 a.m.	1.4	9,100 S., 8,400 E.	1
10	11:19 a.m.	2.5	11,600 S., 10,500 E.	1
10	8:35 p.m.	2.1	11,400 S., 6,500 E.	1
12	7:33 a.m.	1.9	13,000 S., 6,100 E.	3
12	3:38 p.m.	2.8	5,400 S., 3,600 E.	7
12	8:07 p.m.	2.9	14,700 S., 13,500 E.	1
12	11:32 p.m.	2.2	300 S., 8,300 E.	7
14	8:04 a.m.	1.6	10,300 S., 8,700 E.	3
14	5:07 p.m.	2.0	200 S., 5,500 E.	1
15	12:18 p.m.	2.2	6,600 S., 9,600 E.	7
16	4:44 p.m.	1.8	12,100 S., 11,900 E.	3
19	4:55 a.m.	1.7	1,400 S., 7,700 E.	7
19	3:06 p.m.	1.7	13,300 S., 13,000 E.	1
19	5:38 p.m.	1.6	13,900 S., 11,100 E.	7
20	8:06 a.m.	2.4	9,400 S., 13,700 E.	7
21	9:30 a.m.	1.8	14,800 S., 7,100 E.	1
21	10:47 a.m.	1.8	10,700 S., 11,800 E.	1
21	2:20 p.m.	2.3	8,800 S., 19,800 E.	1
22	8:39 a.m.	1.7	10,800 S., 6,800 E.	1
22	10:15 a.m.	2.3	16,100 S., 8,500 E.	7
22	12:03 p.m.	2.1	8,400 S., 1,400 W.	7
22	12:15 p.m.	2.5	11,800 S., 1,800 W.	-1
22	7:12 p.m.	1.7	6,000 S., 500 E.	7
22	7:34 p.m.	2.7	10,900 S., 7,700 E.	1
23	6:57 a.m.	1.8	3,800 S., 3,800 E.	7
24	3:54 a.m.	1.7	900 S., 4,300 E.	7
26	4:05 p.m.	1.5	2,300 S., 7,400 E.	3
27	2:53 p.m.	2.0	1,500 S., 8,100 E.	7
27	3:47 p.m.	1.8	13,600 S., 11,300 E.	7
27	9:33 p.m.	1.6	7,700 S., 1,100 W.	7

Table 2.--Location of earth tremors near the Columbiaand Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
First quarter (Jan., Feb., and March)				
(MST)				
March 29	6:13 p.m.	1.8	10,300 S., 3,000 W.	7
30	3:52 a.m.	2.5	11,200 S., 1,400 E.	1
30	9:47 p.m.	1.6	7,700 S., 12,700 E.	SL
30	10:17 p.m.	1.2	2,000 S., 3,400 E.	7
30	11:29 p.m.	1.1	1,900 S., 4,900 E.	3
31	11:37 a.m.	2.0	12,700 S., 12,900 E.	1
31	8:27 p.m.	2.1	7,900 S., 13,000 E.	3
Second quarter (April, May, and June)				
April 1	11:31 p.m.	1.5	1,000 S., 6,700 E.	1
2	3:50 a.m.	1.5	13,200 S., 15,300 E.	7
2	8:45 p.m.	2.1	13,100 S., 7,600 E.	2
3	6:07 p.m.	2.0	200 S., 6,800 E.	1
4	1:54 a.m.	2.0	11,900 S., 12,300 E.	1
4	5:33 a.m.	1.8	900 S., 4,200 E.	7
4	11:27 a.m.	1.6	100 S., 3,900 E.	7
4	5:38 p.m.	1.7	8,600 S., 8,600 E.	7
6	4:48 p.m.	1.7	12,200 S., 2,000 W.	1
6	4:52 p.m.	1.1	13,100 S., 1,500 W.	1
6	5:20 p.m.	1.3	19,500 S., 1,900 E.	SL
7	10:15 p.m.	1.7	8,000 S., 6,800 E.	3
8	7:40 a.m.	2.2	14,600 S., 16,500 E.	1
8	11:37 a.m.	1.5	15,000 S., 2,800 E.	2
9	6:06 a.m.	2.2	7,600 S., 9,200 E.	2
10	11:01 a.m.	2.3	4,100 S., 14,000 E.	1
10	11:53 p.m.	2.5	9,700 S., 9,800 E.	7
11	0.48 a.m.	1.8	3,800 S., 6,500 E.	-1
11	2:20 a.m.	2.0	3,300 S., 8,500 E.	1
11	8:26 p.m.	1.7	13,700 S., 1,700 E.	SL

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
Second quarter (April, May, and June)				
(MST)				
April 12	0:18 a.m.	1.9	12,200 S., 11,400 E.	1
12	2:56 a.m.	2.4	12,400 S., 1,700 E.	1
12	3:33 a.m.	2.5	4,800 S., 12,600 E.	SL
12	3:50 a.m.	1.8	1,600 S., 2,400 E.	7
12	2:23 p.m.	1.2	10,600 S., 900 E.	3
13	5:14 a.m.	1.9	800 S., 7,300 E.	7
13	3:40 p.m.	2.3	8,300 S., 900 W.	7
13	9:48 p.m.	1.0	12,500 S., 1,600 E.	3
13	9:58 p.m.	1.8	12,800 S., 1,000 W.	1
13	11:54 p.m.	2.1	11,700 S., 13,100 E.	3
15	12:01 p.m.	2.4	5,700 S., 5,400 E.	7
16	1:15 a.m.	2.2	5,600 S., 1,900 E.	3
16	2:30 a.m.	1.4	15,300 S., 3,400 E.	1
17	6:50 a.m.	1.6	17,200 S., 600 W.	2
17	9:18 a.m.	2.0	200 S., 7,500 E.	1
17	6:49 p.m.	2.4	9,000 S., 11,600 E.	2
17	10:17 p.m.	2.0	17,900 S., 4,300 E.	1
18	5:13 a.m.	2.2	12,000 S., 8,200 E.	SL
19	12:00 a.m.	2.1	3,500 S., 13,700 E.	1
19	3:23 p.m.	2.1	5,000 S., 7,400 E.	1
19	9:17 p.m.	1.7	700 S., 5,700 E.	7
20	3:00 a.m.	1.7	300 S., 5,700 E.	7
20	7:02 a.m.	1.8	1,700 S., 10,800 E.	2
21	1:21 a.m.	1.3	18,500 S., 3,200 E.	-1
21	4:37 a.m.	1.4	7,200 S., 7,400 E.	3
21	8:13 a.m.	2.0	4,300 S., 12,000 E.	1
21	11:41 a.m.	2.1	11,400 S., 13,700 E.	7
21	11:41 a.m.	1.9	3,500 S., 13,700 E.	1
21	1:28 p.m.	1.1	14,600 S., 800 W.	1
21	4:55 p.m.	2.9	3,100 S., 11,300 E.	1

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
Second quarter (April, May, and June)				
(MST)				
April 21	6:13 p.m.	2.0	2,100 S., 14,000 E.	1
22	4:37 a.m.	2.3	15,000 S., 11,600 E.	1
23	11:11 p.m.	2.3	11,300 S., 7,000 E.	SL
23	11:31 p.m.	2.5	12,800 S., 12,300 E.	1
24	0:06 a.m.	1.8	16,000 S., 5,500 E.	3
24	0:45 a.m.	1.7	11,200 S., 9,500 E.	1
24	10:10 a.m.	2.0	17,700 S., 5,200 E.	-1
24	4:59 p.m.	1.7	14,100 S., 2,500 E.	1
24	7:03 p.m.	1.0	6,900 S., 1,800 W.	7
25	0:12 a.m.	2.2	15,500 S., 16,600 E.	7
25	8:05 a.m.	2.3	7,000 S., 4,800 E.	3
25	5:10 p.m.	1.1	22,800 S., 100 E.	-1
26	9:13 a.m.	2.6	7,000 S., 14,300 E.	1
27	7:33 p.m.	1.0	24,400 S., 4,100 E.	1
27	8:12 p.m.	1.6	9,700 S., 3,900 W.	7
27	11:51 p.m.	1.0	23,300 S., 6,200 E.	-2
29	6:28 p.m.	2.1	15,600 S., 12,800 E.	3
(MDT)				
30	4:35 p.m.	1.9	14,100 S., 16,100 E.	7
30	10:29 p.m.	1.8	16,500 S., 11,800 E.	1
30	10:29 p.m.	1.8	13,800 S., 10,900 E.	1
May 1	10:21 a.m.	1.5	1,900 S., 1,700 E.	7
1	1:20 p.m.	2.1	19,100 S., 7,500 E.	SL
2	10:18 a.m.	1.0	11,500 S., 1,600 E.	3
3	2:50 a.m.	2.4	5,400 S., 13,600 E.	1
3	1:24 p.m.	2.6	15,000 S., 2,600 E.	SL
4	0:35 a.m.	1.8	10,600 S., 10,900 E.	3
4	5:05 a.m.	1.0	21,500 S., 2,000 E.	1

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
Second quarter (April, May, and June)				
(MDT)				
May 4	6:13 a.m.	2.4	17,000 S., 11,100 E.	7
4	5:45 p.m.	1.8	2,200 S., 6,000 E.	7
4	7:24 p.m.	1.3	900 S., 4,200 E.	7
5	4:30 p.m.	1.8	3,900 S., 18,000 E.	-1
5	5:04 p.m.	2.2	4,200 S., 5,800 E.	3
6	9:23 p.m.	2.2	11,700 S., 12,900 E.	7
7	3:11 p.m.	1.2	19,000 S., 500 E.	7
8	10:45 p.m.	1.1	18,300 S., 2,300 E.	2
9	8:03 a.m.	1.9	2,600 S., 9,900 E.	7
9	10:28 p.m.	1.9	10,800 S., 11,800 E.	3
10	4:41 a.m.	2.7	25,000 S., 4,200 W.	3
10	9:10 p.m.	1.6	12,200 S., 700 E.	1
10	11:08 p.m.	2.3	17,000 S., 2,100 E.	-1
11	1:04 a.m.	2.3	11,200 S., 9,600 E.	3
11	10:05 a.m.	2.3	12,500 S., 17,500 E.	7
12	6:41 a.m.	1.3	14,300 S., 11,300 E.	2
12	12:45 p.m.	1.7	9,600 S., 400 E.	3
12	11:06 p.m.	2.0	14,000 S., 11,300 E.	3
13	10:35 a.m.	2.5	11,700 S., 9,200 E.	SL
13	2:23 p.m.	2.3	1,200 S., 13,700 E.	2
15	1:32 p.m.	1.1	9,000 S., 2,500 W.	3
16	1:06 a.m.	1.0	11,100 S., 1,700 E.	2
16	10:15 a.m.	1.9	12,900 S., 15,200 E.	2
16	1:49 p.m.	1.9	13,500 S., 13,400 E.	3
16	4:49 p.m.	2.0	21,200 S., 5,000 E.	2
16	6:02 p.m.	2.1	26,400 S., 15,600 E.	3
16	9:03 p.m.	2.0	6,900 S., 13,500 E.	SL
17	5:11 a.m.	1.6	21,500 S., 9,300 E.	-1
17	12:34 p.m.	1.2	21,800 S., 5,700 E.	SL
17	12:45 p.m.	1.8	10,600 S., 8,700 E.	7

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1</sup> /
Second quarter (April, May, and June)				
(MDT)				
May 17	1:07 p.m.	2.1	14,100 S., 1,100 W.	3
17	10:22 p.m.	2.5	12,800 S., 11,400 E.	1
18	2:36 p.m.	2.2	4,200 S., 300 E.	7
18	8:35 p.m.	2.1	6,100 S., 5,200 E.	7
19	7:38 a.m.	1.9	8,900 S., 8,800 E.	3
19	1:19 p.m.	2.1	11,300 S., 14,500 E.	3
20	4:20 a.m.	1.4	13,000 S., 3,300 E.	2
20	7:03 a.m.	1.9	7,500 S., 5,100 E.	SL
20	6:57 p.m.	1.6	11,700 S., 9,600 E.	7
23	10:19 a.m.	2.1	16,800 S., 2,600 E.	SL
23	6:41 p.m.	2.1	23,500 S., 4,400 E.	1
23	9:31 p.m.	2.1	11,500 S., 9,900 E.	1
23	11:41 p.m.	2.3	16,400 S., 16,600 E.	3
24	4:08 a.m.	1.7	10,200 S., 900 E.	3
24	1:01 p.m.	2.2	16,900 S., 100 W.	1
25	3:33 a.m.	3.0	16,300 S., 14,500 E.	1
25	3:45 a.m.	1.9	19,400 S., 9,500 E.	1
25	4:19 a.m.	2.4	17,800 S., 8,900 E.	SL
25	4:41 a.m.	1.8	17,900 S., 3,900 E.	1
25	10:35 p.m.	2.4	7,300 S., 4,800 E.	1
26	12:52 a.m.	2.0	6,400 S., 3,700 E.	2
26	3:45 a.m.	1.4	8,500 S., 1,100 E.	3
27	8:48 a.m.	2.0	11,100 S., 7,200 E.	2
27	12:20 p.m.	1.9	13,500 S., 7,000 E.	SL
27	1:57 p.m.	1.1	24,600 S., 5,200 E.	1
28	9:18 p.m.	2.3	5,700 S., 4,200 E.	7
29	9:16 a.m.	2.5	16,800 S., 16,300 E.	2
30	7:43 p.m.	1.6	13,300 S., 10,700 E.	1
31	5:39 a.m.	1.2	8,400 S., 100 W.	7
June 1	3:16 a.m.	1.2	5,800 S., 2,800 E.	7

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /	
Second quarter (April, May, and June)					
(MDT)					
June	1	3:34 a.m.	1.6	14,300 S., 11,200 E.	3
	1	6:44 a.m.	1.8	13,600 S., 13,800 E.	7
	2	1:05 p.m.	1.7	11,500 S., 11,200 E.	7
	2	4:00 p.m.	1.8	2,200 S., 900 E.	7
	2	11:24 a.m.	2.1	15,200 S., 18,300 E.	7
	3	2:11 p.m.	1.6	22,200 S., 4,200 E.	SL
	3	5:39 p.m.	1.3	13,800 S., 2,300 W.	7
	3	9:45 p.m.	1.6	19,900 S., 8,200 E.	SL
	4	1:29 a.m.	2.2	12,100 S., 9,800 E.	1
	4	1:32 p.m.	1.7	2,800 S., 500 W.	7
	4	2:11 p.m.	1.3	10,200 S., 100 E.	7
	7	2:40 p.m.	2.3	11,100 S., 21,000 E.	3
	7	7:58 p.m.	2.3	12,000 S., 11,100 E.	2
	7	8:33 p.m.	2.4	6,400 S., 10,200 E.	3
	8	7:31 p.m.	2.1	9,200 S., 7,700 E.	1
	9	6:01 p.m.	1.8	7,500 S., 10,600 E.	3
	9	6:10 p.m.	1.2	22,500 S., 4,600 E.	1
	10	9:24 a.m.	1.9	13,400 S., 11,800 E.	3
	10	10:49 a.m.	1.1	16,500 S., 2,700 E.	1
	10	9:38 p.m.	2.2	2,600 S., 6,000 E.	1
	12	2:13 a.m.	1.5	16,700 S., 9,800 E.	1
	12	6:37 a.m.	1.3	10,500 S., 10,600 E.	7
	12	4:45 p.m.	1.5	20,100 S., 12,500 E.	5
	12	5:36 p.m.	1.9	12,700 S., 11,700 E.	SL
	12	8:03 p.m.	1.6	9,500 S., 6,300 E.	1
	13	4:25 p.m.	2.1	14,300 S., 16,600 E.	5
	14	8:01 a.m.	2.3	11,700 S., 8,500 E.	SL
	14	2:09 p.m.	2.5	14,400 S., 13,900 E.	6
	14	10:17 p.m.	2.4	9,500 S., 9,000 E.	SL
	16	3:45 a.m.	1.8	16,800 S., 6,900 E.	4



Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sub>1</sub> /
Second quarter (April, May, and June)				
(MDT)				
June 16	9:44 p.m.	2.4	10,900 S., 10,300 E.	7
16	9:55 p.m.	2.2	13,500 S., 13,100 E.	2
17	1:08 a.m.	1.8	12,000 S., 19,300 E.	7
17	1:42 a.m.	1.7	6,000 S., 19,600 E.	SL
19	4:10 a.m.	1.3	17,300 S., 7,700 E.	-1
19	10:13 a.m.	2.1	13,500 S., 10,300 E.	1
19	12:42 p.m.	1.6	11,900 S., 14,300 E.	7
19	3:43 p.m.	1.9	13,200 S., 8,300 E.	1
22	2:07 a.m.	1.6	18,700 S., 2,400 E.	SL
23	5:53 p.m.	1.2	18,700 S., 3,300 E.	1
24	3:29 p.m.	2.1	9,700 S., 10,500 E.	3
25	8:29 a.m.	1.9	14,200 S., 4,000 E.	1
25	12:20 p.m.	1.3	11,100 S., 4,100 W.	1
26	5:25 a.m.	1.2	9,600 S., 1,700 W.	7
26	8:51 p.m.	2.9	20,100 S., 800 W.	SL
26	9:11 p.m.	1.8	10,500 S., 2,700 W.	3
26	9:56 p.m.	2.4	11,700 S., 3,000 W.	7
27	4:12 a.m.	2.3	11,600 S., 3,600 W.	7
30	12:57 a.m.	1.1	26,000 S., 1,300 E.	3

Third quarter (July, Aug., and Sept.)

July 1	8:21 a.m.	2.4	11,700 S., 8,700 E.	1
1	8:26 p.m.	2.0	16,100 S., 2,500 W.	7
2	8:25 a.m.	1.6	13,700 S., 100 E.	7
2	1:53 p.m.	2.2	13,800 S., 5,700 E.	7
3	5:49 p.m.	1.3	18,900 S., 500 E.	1

Table 2.--Location of earth tremors near the Columbiaand Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
Third quarter (July, Aug., and Sept.)				
(MDT)				
July 5	11:18 p.m.	1.8	1,100 S., 2,900 E.	7
Aug. 28	9:58 a.m.	1.2	9,600 S., 300 W.	7
28	8:36 p.m.	1.1	21,000 S., 600 E.	3
Sept. 21	3:40 p.m.	1.4	11,000 S., 2,900 W.	7
22	5:54 p.m.	1.7	10,300 S., 1,300 W.	7
29	8:13 a.m.	1.7	10,300 S., 100 E.	3
Fourth quarter (Oct., Nov., and Dec.)				
Oct. 5	2:12 a.m.	1.4	11,700 S., 1,800 E.	1
13	9:27 p.m.	1.4	14,100 S., 2,700 E.	3
13	9:29 p.m.	1.8	15,800 S., 13,200 E.	1
18	4:20 a.m.	1.7	22,700 S., 6,200 E.	3
19	5:46 p.m.	1.0	16,800 S., 3,500 E.	1
22	4:29 p.m.	2.4	16,500 S., 1,300 W.	<u>2/1</u>
24	6:56 p.m.	2.8	24,800 S., 3,200 E.	<u>2/1</u>
24	7:33 p.m.	2.9	23,000 S., 2,900 E.	<u>2/1</u>
24	7:37 p.m.	1.3	22,800 S., 3,000 E.	1
24	8:17 p.m.	2.8	22,000 S., 3,000 E.	<u>2/SL</u>
24	8:41 p.m.	2.8	24,500 S., 3,000 E.	<u>2/3</u>
24	8:45 p.m.	1.5	27,100 S., 7,000 E.	<u>2/3</u>
24	11:53 p.m.	2.8	23,600 S., 4,500 E.	<u>2/3</u>
24	12:06 a.m.	2.3	22,200 S., 2,900 E.	<u>2/SL</u>
(MST)				
Nov. 2	8:49 a.m.	2.1	13,100 S., 13,000 E.	3
5	12:34 p.m.	1.8	13,100 S., 800 W.	1
14	8:57 a.m.	2.3	14,500 S., 11,600 E.	1
15	8:57 a.m.	2.5	8,000 S., 2,800 E.	<u>2/1</u>
20	9:05 p.m.	1.0	20,900 S., 7,900 E.	7

Table 2.--Location of earth tremors near the Columbia  
and Geneva Mines during 1967--Continued

Date	Time	Richter magnitude	Coordinates in feet	Depth of tremor foci above or below (-) sea level, in thousands of feet <sup>1/</sup>
Fourth quarter (Oct., Nov., and Dec.)				
(MST)				
Nov. 20	9:50 p.m.	1.7	13,200 S., 6,600 E.	-1
24	5:00 a.m.	2.2	5,000 S., 4,700 E.	<u>2/6</u>
29	2:10 p.m.	1.8	13,100 S., 6,700 E.	1
30	1:16 a.m.	1.3	24,100 S., 3,600 E.	2
Dec. 1	10:42 a.m.	1.7	12,300 S., 100 E.	7
1	3:29 p.m.	1.3	21,000 S., 1,300 E.	SL
3	10:21 a.m.	2.0	20,900 S., 3,400 E.	1
3	2:16 p.m.	1.0	20,500 S., 2,000 E.	3
4	5:09 a.m.	2.2	7,400 S., 1,300 E.	<u>2/7</u>
5	11:45 p.m.	2.7	6,500 S., 1,500 E.	<u>2/7</u>
7	3:31 p.m.	2.5	8,100 S., 2,000 E.	<u>2/7</u>
8	7:40 a.m.	1.9	21,300 S., 2,600 E.	<u>2/1</u>
8	8:17 p.m.	2.2	8,300 S., 2,000 W.	<u>2/7</u>
8	10:03 p.m.	2.3	6,300 S., 2,200 E.	<u>2/7</u>
11	1:35 a.m.	1.6	13,700 S., 2,600 W.	7
11	1:40 p.m.	1.9	16,400 S., 3,800 W.	7
14	11:00 a.m.	1.0	8,900 S., 1,300 W.	7
16	4:46 a.m.	1.0	13,000 S., 3,100 W.	7
20	2:00 a.m.	1.0	20,100 S., 2,600 E.	<u>2/1</u>

<sup>1/</sup>SL, sea level (focus datum).

<sup>2/</sup>Magnetic tape playback solution.