GEOLOGICAL SURVEY CIRCULAR 717–C

Seismic Engineering Program Report, July–September 1975

Prepared on behalf of the
National Science Foundation

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United States Department of the Interior

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Geological Survey

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PREFACE

This Seismic Engineering Program Report is an informal document intended to keep the ever-growing community of strong-motion data users apprised of the activities and data recovered by the U.S. Geological Survey in the Seismic Engineering Program of strong-motion instrumentation supported by the National Science Foundation (Grant CA-114) in cooperation with other Federal, State, and local agencies and organizations.

This report contains a list of the accelerograph records recovered during the second quarter of 1975, preliminary reports on earthquakes from which significant accelerograph records were recovered, and information on the availability of digitized data. Future issues will contain similar information with all listed data as current as practicable under the constraints of the U.S.G.S. review and publication procedures.

SEISMIC ENGINEERING PROGRAM REPORT, JULY-SEPTEMBER 1975

ACCELEROGRAPH RECORDS APRIL - JUNE, 1975

By R. P. Maley and B. L. Silverstein

During the second quarter of 1975, 29 accelerograph records were obtained from the strong-motion instrumentation network operated by the U.S. Geological Survey for the National Science Foundation in cooperation with other federal, state, and local agencies and organizations. This total represents the data recovered from 11 earthquakes ranging in magnitude from 3.6 to 6.0 that occurred in California, Alaska, Missouri, and Puerto Rico. Table 1 presents a chronological summary of the records including the maximum accelerations for those records in which peak accelerations equaled or exceeded 0.05g on the ground or 0.10g on a structure.

The first known strong-motion accelerograph record obtained from an earthquake in the central United States was recorded during a magnitude 3.8 shock that occurred in southeastern Missouri on June 13. Maximum accelerations of 0.07g and 0.06g were registered by the horizontal components. The calculated epicentral distance, based upon information from St. Louis University (S. Morrissey, oral commun, 1975), was 10 km. The S-wave minus trigger interval, which approximates the S-P interval within about a tenth of a second, was 0.3 second, indicating that the source-to-receiver distance was relatively small.

Two minor records were recovered at San Juan, Puerto Rico, from a magnitude 4.9 earthquake that occurred an estimated 110 km away.

Several accelerograms obtained from California Institute of Technology stations during the Imperial Valley earthquake swarm of June 19 and 20 are not included in table 1 because the original records are not processed or archived by the U.S. Geological Survey, although the more significant results from these records are presented in a preliminary report, below.

PRELIMINARY REPORT ON THE IMPERIAL VALLEY EARTHQUAKE SWARM OF JUNE 19 AND 20, 1975

By Ronald L. Porcella and Edwin C. Etheredge

A swarm of earthquakes occurred in the Imperial Valley near El Centro, California on June 9 and 20, 1975. The largest shock had a magnitude of 4.2 (PAS) and occurred at 22:48 local time (PDT) Thursday, June 19, 1975. The epicenter was approximately 10 km east of El Centro at 32.77° N and 115.44° W. A second shock of 4.1 magnitude occurred the following afternoon at 15:15 (PDT) at 32.78° N and 115.43° W (fig. 1). Both shocks rattled windows and operated burglar alarms in the area but caused no reported damage (Imperial Valley Press, June 21, 1975). Seven strong-motion accelerographs maintained by the U.S. Geological Survey and the California Institute of Technology (CIT) Earthquake Engineering Research Laboratory were triggered by the series of earthquakes. In all, 10 accelerograph records and 3 seismoscope records were recovered from stations located between 5 and 15 km of the two epicenters.

A similar swarm of earthquakes beginning on January 23, 1975 produced records at four accelerograph stations in the El Centro-Imp-

erial area. Since that time 13 new stations have been established in the Imperial Valley by the USGS, CIT, and the California Division of Mines and Geology. Most of the new instruments are alined transverse to the Imperial fault zone at approximately 3-km separations (fig. 1). These instruments complement an array along the fault installed by CIT. Each instrument will be equipped with a vertical trigger and will have real time impressed on the records by WWVB radio receivers.

The largest accelerations were recorded during the magnitude 4.1 earthquake: 0.13g at El Centro Array Sta 6, and 0.15g at Holtville (table 2). The largest earthquake, magnitude 4.2, registered somewhat smaller accelerations at the two sites: 0.10g at El Centro Array Sta 6, and 0.07g at Holtville. Note that instruments located at shorter epicentral distances such as El Centro Array: Sta 7 and Sta 8 (fig. 1) were not triggered by either event. This indicates that vertical acceleration did not exceed 0.01g at these sites. A third shock, magnitude 3.6 on June 20, registered maximum accelerations of 0.03g at both Holtville and El Centro Array Sta 6.

The initial shear-wave motion on the horizontal components shown in figure 2 typically displays the relatively long period (2-3hz), high-amplitude characteristics associated with the shallow-focus, low-magnitude earthquakes in this region.

Because a number of the instruments operating during this earthquake series were equipped with vertical triggers, it is possible to identify S-wave minus trigger intervals, which ranged from 0.65 - 3.40 seconds. No such intervals were observed on the January 23 records when only horizontal triggers were being used.

During this investigation, six zones along the Imperial fault trace were inspected for evidence of recent ground displacement. The features checked were roadway surfaces and concrete-lined irrigation ditches. Of the six zones, five showed some previous horizontal displacement due to sudden faulting and/or creep. These same five locations had been previously noted by Brune and Allen (1967) as being areas where lateral offset was directly related to sudden faulting during the March 4, 1966 Imperial earthquake, which occurred 5 km west of the June 1975 epicenters. At two locations, 2 km north and 6 km south of El Centro Array: Sta 7 (fig. 1), en echelon cracking in roadway surfaces indicated small right-lateral displacements; however, none of the zones showed any evidence of renewed ground displacement that could be attributed specifically to the June 1975 earthquake activity. Numerous detailed photographs were taken of these localities for possible use in future offset determinations.

Reference

Brune, J. N. and Allen, C. R., 1967, A low-stress-drop, low-magnitude earthquake with surface faulting; the Imperial, California earthquake of March 4, 1966: Seismol. Soc. America Bull., v. 57, p. 510-514.

PRELIMINARY SUMMARY OF STRONG-MOTION DATA FROM THE OROVILLE EARTHQUAKE OF 1 AUGUST 1975

By Richard P. Maley, B. J. Morrill, Russell Forshee, William Wells[1], Harry LaGesse[1], and Ross Stevens[2]

A strong earthquake occurred in north-central California at 1320 Pacific Daylight Time (2020 GMT) on August 1, 1975. The University of California, Berkeley seismograph station reported the following information about the event: magnitude 5.7; location 39.44° N and 121.53° W, approximately 8 km south of Oroville.

The earthquake was recorded by five strong-motion accelerographs located less

[1] California Division of Mines and Geology

[2] California Department of Water Resources

than 35 km from the epicenter including two instruments installed at and near Oroville Dam approximately 12 km northeast of the epicenter (fig. 3). The Oroville Dam accelerographs, operated in a cooperative program between the California Department of Water Resources and USGS, are located on the dam crest and at a seismograph vault approximately 2 km northwest of the dam. A third instrument in the core block of the dam was inoperative at the time of the earthquake. The records from the seismograph vault and crest stations (fig. 4 and 5) show about 2-3 seconds of significant motion with maximum acceleration spikes of 0.13g at both sites. Other than these few peaks the nominal acceleration values were somewhat less than 0.10g. The crest instrument had a delayed start and consequently a few seconds of data were lost during the early part of the earthquake. Note, that the top trace in figure 5 was recorded transverse to the axis of the dam, whereas the bottom trace was parallel to the axis. Table 3 summarizes the maximum acceleration values scaled from the more significant records. The two Oroville Dam records have been digitized for further processing and analysis.

Three other records were obtained from California Division of Mines and Geology instruments located north and south of the epicenter at distances between 28 and 34 km (fig. 3 and table 3). At two alluvial sites, Chico to the north and Marysville to the south, peak accelerations of 0.08g and 0.07g, respectively, were recorded, whereas at a rock site, Paradise, the maximum acceleration was 0.04g. The instrument at Sutter Buttes, which was installed in a building erected on volcanic rock, was operational but was not triggered by the earthquake. Because the vertical trigger at this site is calibrated to start the instrument at 0.01g, it is assumed that at least the vertical accelerations were somewhat less than this value.

Several other smaller records were obtained from outlying stations as far away as Sacramento, Calif. and Reno, Nev. A minor foreshock record was recorded at Oroville Dam crest, and a number of aftershocks were recorded at the dam and at Chico and Marysville.

Seismoscope records were obtained from five stations operated in the Oroville area in cooperation with the California Department of Water Resources (fig. 6). With the exception of the Division of Highways (DOH), records from each of the stations were recovered shortly after the main earthquake. Although normally there is no separation of earthquakes recorded on a seismoscope plate, the magnitude of shocks before and after the main earthquake suggests that the records represent principally the motion of a single earthquake. Copies of the records are shown in figure 7.

The record from DOH was not picked up until August 4, and consequently it contains motion from all prior events. Because there was an offset in the zero position of the stylus, either during the later part of the main earthquake or some time shortly thereafter, there is a definite separation in the records. The offset indicates an apparent tilting of 5° down to the southeast. Examination of the instrument showed that it was in good condition and that the stylus arm knife edges were still properly seated in the pivots. The reason for the zero position offset is not yet known. An apparent original error in reported orientation of the DOH record has been corrected in figure 7 and table 4 by a 50° clockwise rotation. This error was discovered by a comparison of the zero position on aftershock records.

The DOH record exhibited a prominent pulsing or excitement of the natural frequency of the pendulum suspension which, in effect, places a time scale on the record. This will permit recovery of the acceleration time-history in later analysis. Other seismoscope records have this characteristic, and analyses of them will be performed.

Although the seismoscope is intended to record only motion in the horizontal plane, a crude measure of the degree of relative vertical motion between the various sites

can be made by comparing the number of times the stylus lifted off the record. A count of these skips suggests that the seismoscope at DOH received considerable vertical motion.

Table 4 lists the seismoscope results. The displacement values ranged from 0.9-4.2 cm and showed an apparent correlation with soil conditions, that is, those instruments on unconsolidated sediments recorded higher displacements than those on volcanic rock.

THE PLEASANT VALLEY PUMPING PLANT RECORDS FROM THE THREE ROCKS EARTHQUAKE OF AUGUST 3, 1975

By R. B. Matthiesen

A magnitude 4.8 earthquake occurred on August 3, 1975 at 36° 27.5'N and 120° 20.7' W near Three Rocks, Calif. (data from the University of California, Berkeley seismograph station). Four strong-motion accelerograph records were obtained at the Pleasant Valley Pumping Plant of the Central Valley Water Project. Copies of the records are shown in figure 8.

Although these records are of small amplitude, the obvious differences in the character of the record from the switchyard compared to those from the base and ground level of the plant and the clear indication of modal response in the roof record suggest that these records may of significant value in a study of soil-structure interaction. The structure consists of a massive concrete base containing the intake tubes and pump units below grade, and a moment-resistant steel frame superstructure with reinforced brick up to the level of the overhead crane rails. The relative simplicity of the structure and its response suggests that further analyses and interpretation of these records will be relatively straightforward. The records are being digitized, and additional details on the structure and the site conditions are being obtained.

AVAILABILITY OF DIGITIZED DATA

The February 9, 1971 San Fernando earthquake strong-motion records and most of the significant records prior to that earthquake have been digitized by the California Institute of Technology (CIT). The digitized data are presently available through CIT and the Environmental Data Service (EDS) of the National Oceanic and Atmospheric Administration (NOAA) in the following forms:

California Institute of Technology:

* Volume I form of data (uncorrected) is available on four magnetic tapes at a total cost of $400.
* Volume II form of data (corrected) is available for 329 records on three magnetic tapes at a total cost of $300.
* Data are available on seven-track, 800 BPI formatted tape in BCD; a few other formats are also available.
* Inquiries should be addressed to:
  Earthquake Engineering Research Lab.
  California Institute of Technology
  Mail Code 104-44
  Pasadena, CA 91125
  (213) 795-6841, ext. 1232

Environmental Data Service:

* Volume I form of data (uncorrected) is available in punched card form (about 2000 cards each) for $20 per event and on magnetic tape (seven- or nine-track) for $60 per tape. The complete file of approximately 400 records is available on six magnetic tapes for $360.
* Inquiries should be addressed to:
  National Geophysical and Solar-Terestrial Data Center
  EDS/NOAA, Code 62
  Boulder, CO 80302
  (303) 499-1000, ext. 6472

Significant strong-motion records obtained since the San Fernando earthquake are being processed by the USGS. The availability of such data will be announced in subsequent Program Reports.

Table 1 - *Summary of accelerograph records: April-June 1975*

Event	Station location Name	Coord	S-t time[1] (sec)	Comp	Max accl[2] (g)	Duration[3] (sec)
6 May 1975 Cape Mendocino 40.25N, 124.67W Magnitude 4.0	Shelter Cove: Sta 1	40.04N 124.06W	5.6	N70W Down S20W	.06 .03 .06	
	Shelter Cove: Sta 2 Power Plant Yard	40.03N 124.06W	5.6	S20E Down N70E	.09 .08 .18	0.4
12 May 1975 Maricopa 35.00N, 119.06W Magnitude 4.5	Mount Able Kern County Park	34.83N 119.28W	2.7	S04W Down S86E	.03 .02 .07	
	Small-amplitude records were also obtained at Mettler Ranch, Elkhorn Scarp, Rudnick Ranch, and Buena Vista Pumping Plant.					
18 May 1975 So cent Alaska 63.2N, 151.3W Magnitude 6.0	A small-amplitude record was obtained at Talkeetna.[4]					
31 May 1975 Mojave Desert 34.51N, 116.46W Magnitude 5.2	A small-amplitude record was obtained at Amboy.					
7 June 1975 Humboldt County 40.54N, 124.29W Magnitude 5.5	Ferndale Old City Hall	40.58N 124.26W		Up S44W N46W	.19 .05 .24	
	Cape Mendocino Petrolia	40.35N 124.35W		S60E Down N30E	.22 .03 .14	1.1 1.8
	Petrolia General Store	40.32N 124.29W		N75E Down N15W	.19 .03 .13	1.7 1.9
	Shelter Cove: Sta 2 Power Plant Yard	40.03N 124.06W		S20E Down N70E	.10 - .07	1 peak
	Small-amplitude records were also obtained at Butler Valley: Sta 1, Shelter Cove: Sta 1, Rockport, and a partial record at Eureka: Federal Building.					

see footnotes at the end of table.

Table 1 - *Summary of accelerograph records: April-June 1975* - Continued

Event	Station location Name	Coord	S-t time[1] (sec)	Comp	Max accl[2] (g)	Duration[3] (sec)
10 June 1975 So cent Alaska 62.1N, 149.9W Magnitude 4.4	A small-amplitude record was obtained at Summit.[4]					
13 June 1975 SE Missouri 36.54N, 89.68W Magnitude 4.3	New Madrid Noranda Aluminum Plant	36.51N 89.57W	0.3	S19W Down N71W	.06 .04 .07	
17 June 1975 Puerto Rico 19.10N, 66.85N Magnitude 4.9	Small-amplitude records obtained from San Juan, VA Hospital and the Capacete-Martin Building.					
19 June 1975 Imperial Valley 32.77N, 115.44W Magnitude 4.2	El Centro Array: Sta 6 551 Huston	32.84N 115.49W	2.7	S52W Down S38E	.06 .02 .10	1 peak
	El Centro Meadows Union School 2059 Bowker	32.80N 115.47W	0.7	S52W Down S38E	.06 .02 .04	
	Small-amplitude records were also obtained from El Centro: Imperial Valley Irrigation District Substation, and El Centro Array: Sta 11.					
20 June 1975 Imperial Valley 1415 PST 32.78N, 115.43W Magnitude 4.1	El Centro Array: Sta 6 551 Huston	32.84N 115.49W	3.1	S52W Down S38E	.10 .05 .13	.1 .3
	A small-amplitude record was also obtained at El Centro, Imperial Valley Irrigation District Substation.					
20 June 1975 1855 PST Imperial Valley 32.77N, 115.43W Magnitude 3.6	A small-amplitude record was obtained at El Centro Array: Sta 6.					

[1] S-wave minus trigger time.

[2] Unless otherwise noted, maximum acceleration recorded at ground or basement level. Data from the records are summarized only if the maximum acceleration is greater than 0.05 g at ground stations or greater than 0.10 g at upper floors of buildings.

[3] Duration for which peaks of acceleration exceed 0.10 g.

[4] These records could not be positively identified with the listed earthquakes.

Table 2 - *Summary of accelerograph records from the Imperial Valley earthquake swarm of June 19 and 20, 1975*

Station	Maximum acceleration (g)	S-wave minus trigger time (sec)	Epicentral distance (km)
	Earthquake of June 19, magnitude 4.2		
Meadows Union School	.04	.65	5.0
Holtville	.07	2.30	6.4
El Centro: Sta 3	Not triggered	-	-
El Centro: Sta 6	.10	2.70	9.6
El Centro: Sta 9	.03	-[1]	11.4
El Centro: Sta 11	.03	2.95	15.1
Calexico	.03	1.40	12.4
	Earthquake of June 20, magnitude 4.1		
Meadows Union School	Not triggered	-	-
Holtville	.15	2.20	5.7
El Centro: Sta 3	.03	3.40	13.1
El Centro: Sta 6	.13	3.05	8.7
El Centro: Sta 9	.01	-[1]	11.3
El Centro: Sta 11	Not triggered	-	-
Calexico	Not triggered	-	-

[1]Instrument equipped with a horizontal starter so that the S-wave minus trigger interval is not meaningful.

Table 3 - *Summary of accelerograph data from stations within 50 km of the Oroville earthquake*

Station	Instrument	Epicentral distance (km)	Soil	Component	Maximum accel (g)	Remarks
Chico	SMA-1	33	Alluvium	S33W Down S57E	.08 .03 .06	
Marysville	SMA-1	32	Alluvium	S85W Down S05E	.07 .04 .06	
Oroville Dam crest	AR-240	11	Earthfill dam	N46E Down N44W	.12 .13 .09	First few seconds of record lost
Oroville Dam seismograph station	USC&GS Standard	12	Meta-volcanic rock	N53W Up N37E	.10 .13 .11	
Paradise	SMA-1	32	Volcanic	S07E Down N83E	.03 .03 .04	
Sutter Buttes	SMA-1	35	Rock (andesite porphyry)			Was not triggered

Table 4 - *Summary of seismoscope results from the Oroville earthquake*

Station	Direction to epicenter (degrees)	Epicentral distance (km)	Soil	S_d (cm)	S_d direction (degrees)
Division of Highways	150	7.5	Alluvium	4.2	238[1]
Division of Forestry	161	10.6	Compacted clay, silt, and sand	2.7	047
Fire station	163	8.2	Compacted clay, silt, and sand	1.6	275
Hill residence	181	9.7	Volcanic and sedimentary rock	1.0	270
Seismograph station	190	12.5	Meta-volcanic rock	0.9	106

[1]Corrected 50° clockwise.

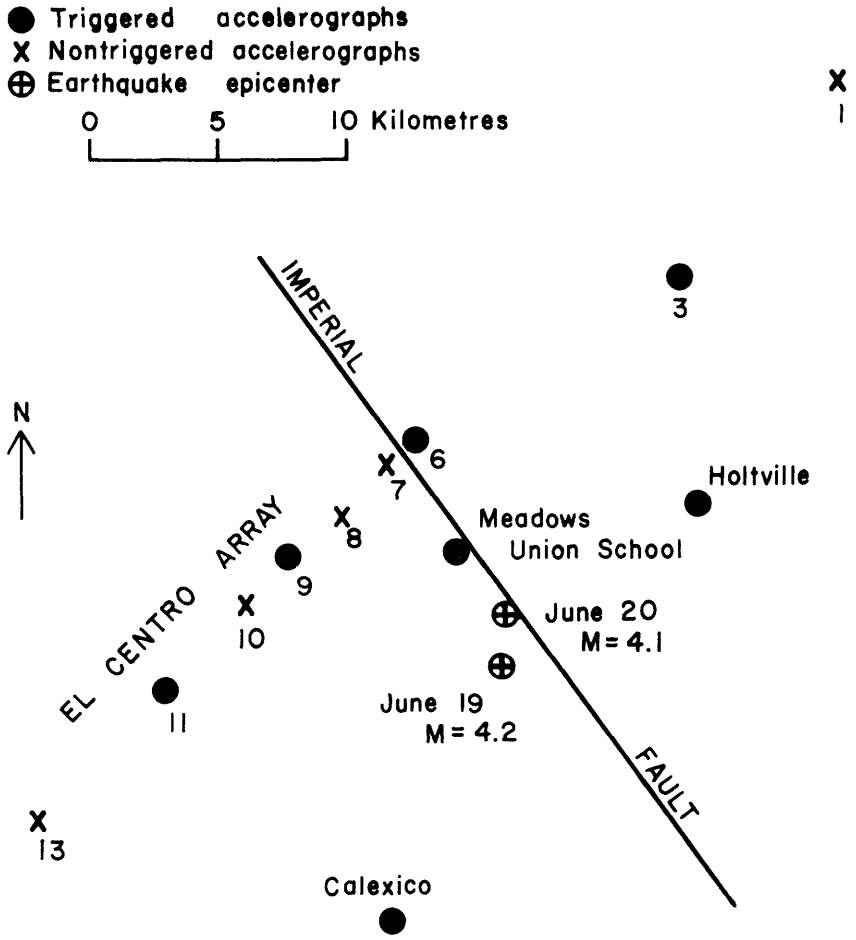

Figure 1. Accelerograph stations located in Imperial Valley during the earthquakes of June 19 and 20, 1975.

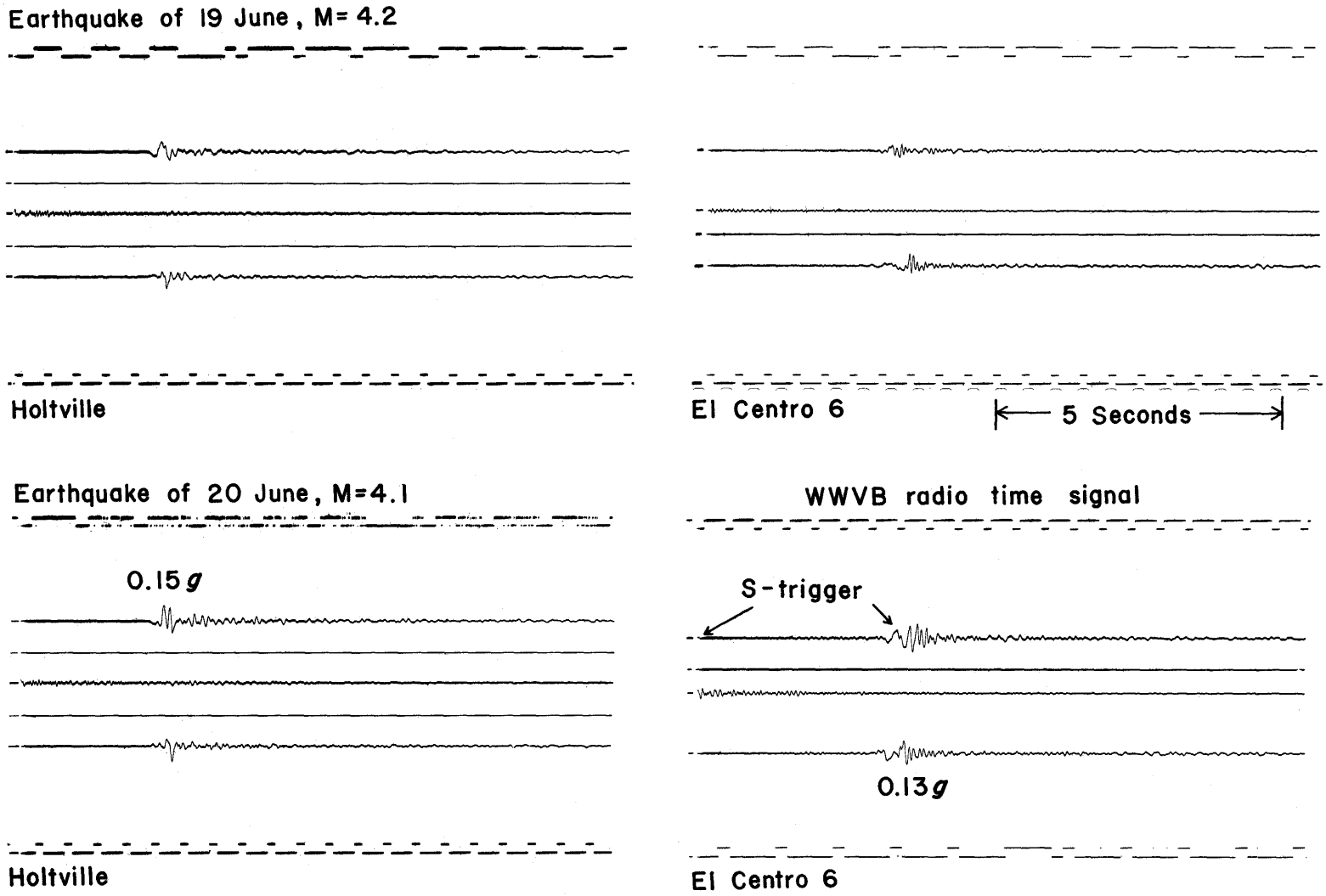

Figure 2. Holtville and El Centro accelerograph records from the earthquakes of June 19 and 20, 1975.

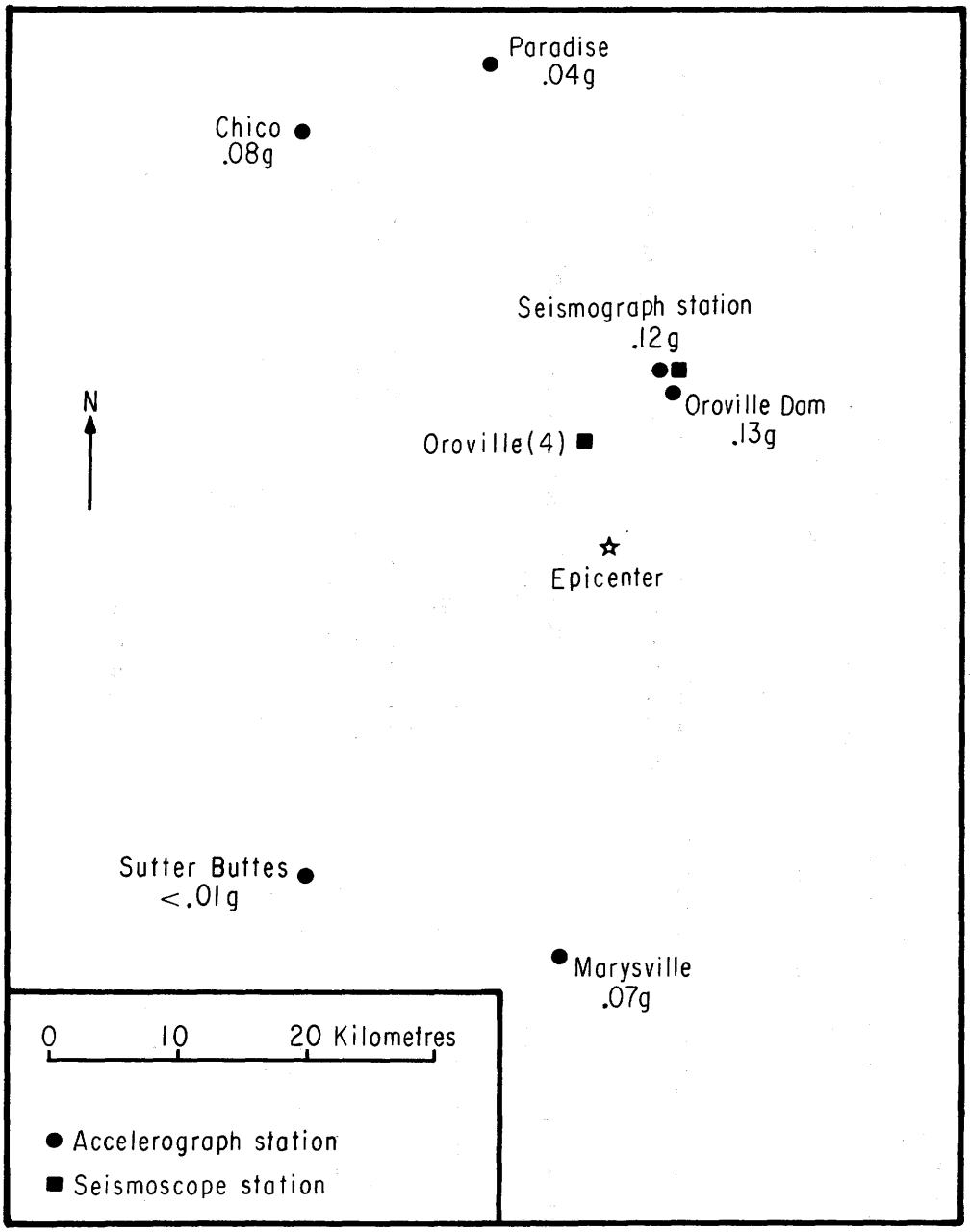

Figure 3. Location of strong-motion accelerographs near the Oroville earthquake; peak recorded accelerations are shown below the station names. No record was obtained at Sutter Buttes, consequently the maximum acceleration at this site is assumed to be less than the instrument's triggering threshold of 0.10g.

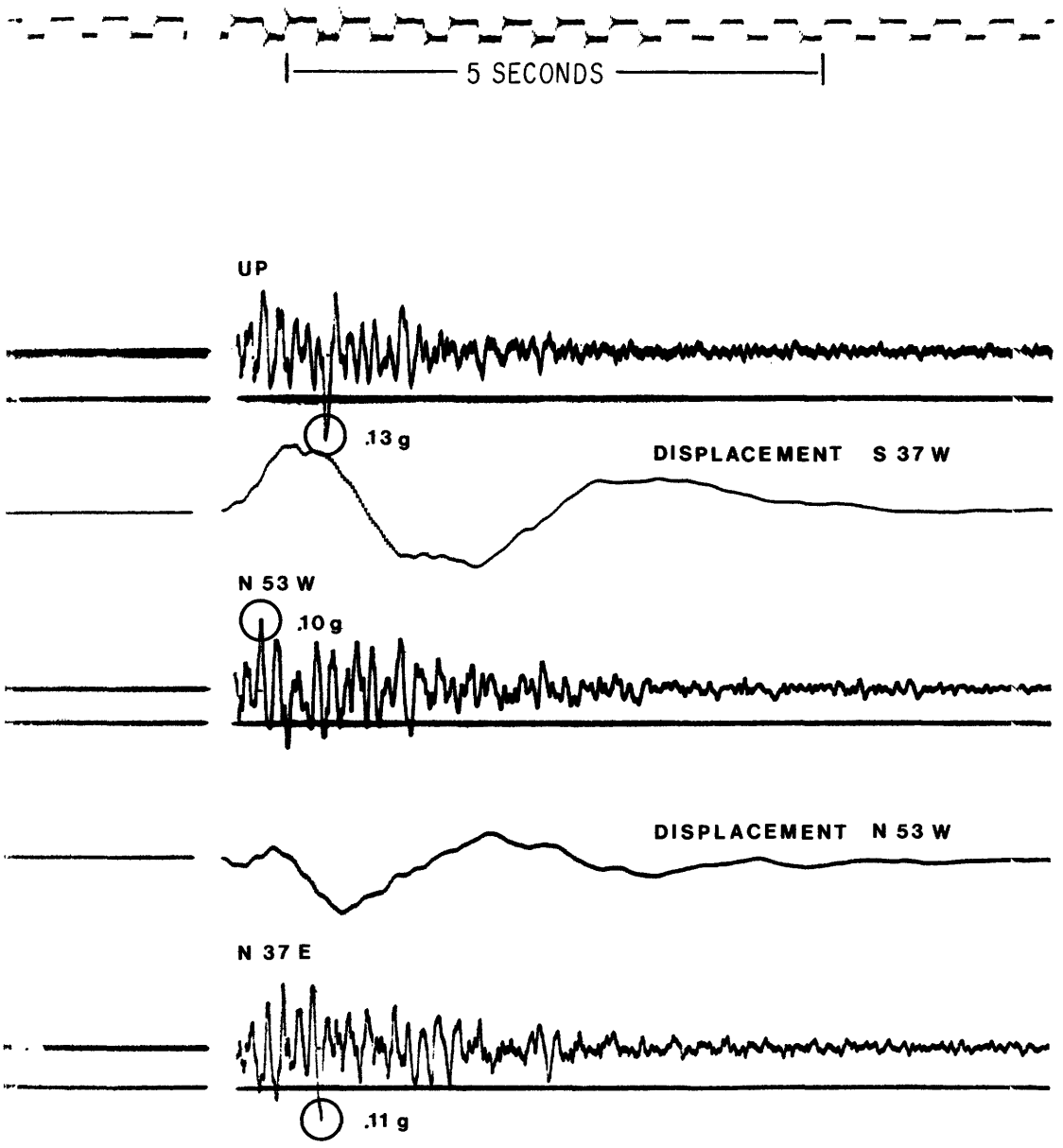

Figure 4. Tracing of the accelerograph record from the Oroville seismograph station about 2 km northwest of the dam.

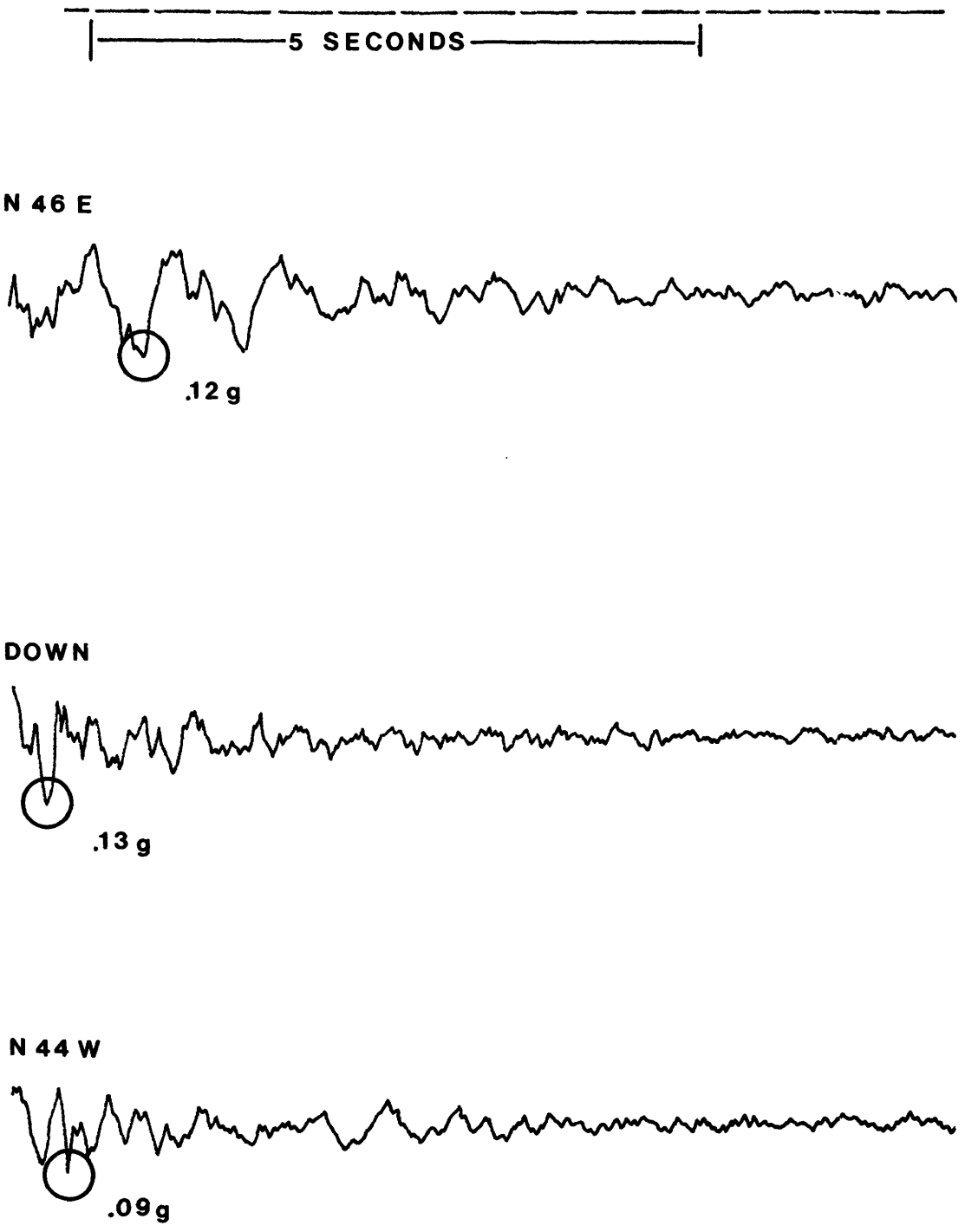

Figure 5. Tracing of the accelerograph record from the crest of Oroville Dam.

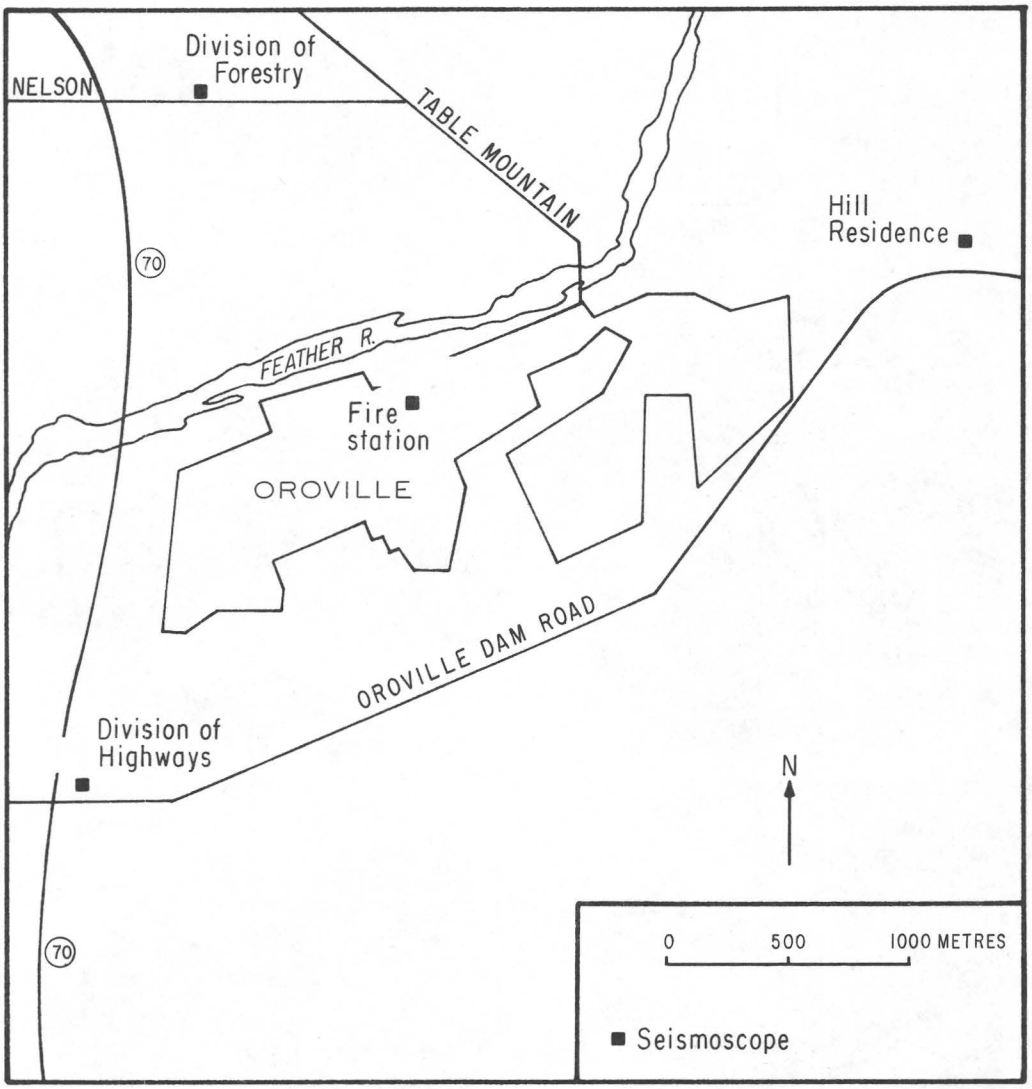

Figure 6. Sites of the four seismoscopes installed in the Oroville area. A fifth instrument is located near Oroville Dam, 7 km northeast of the city.

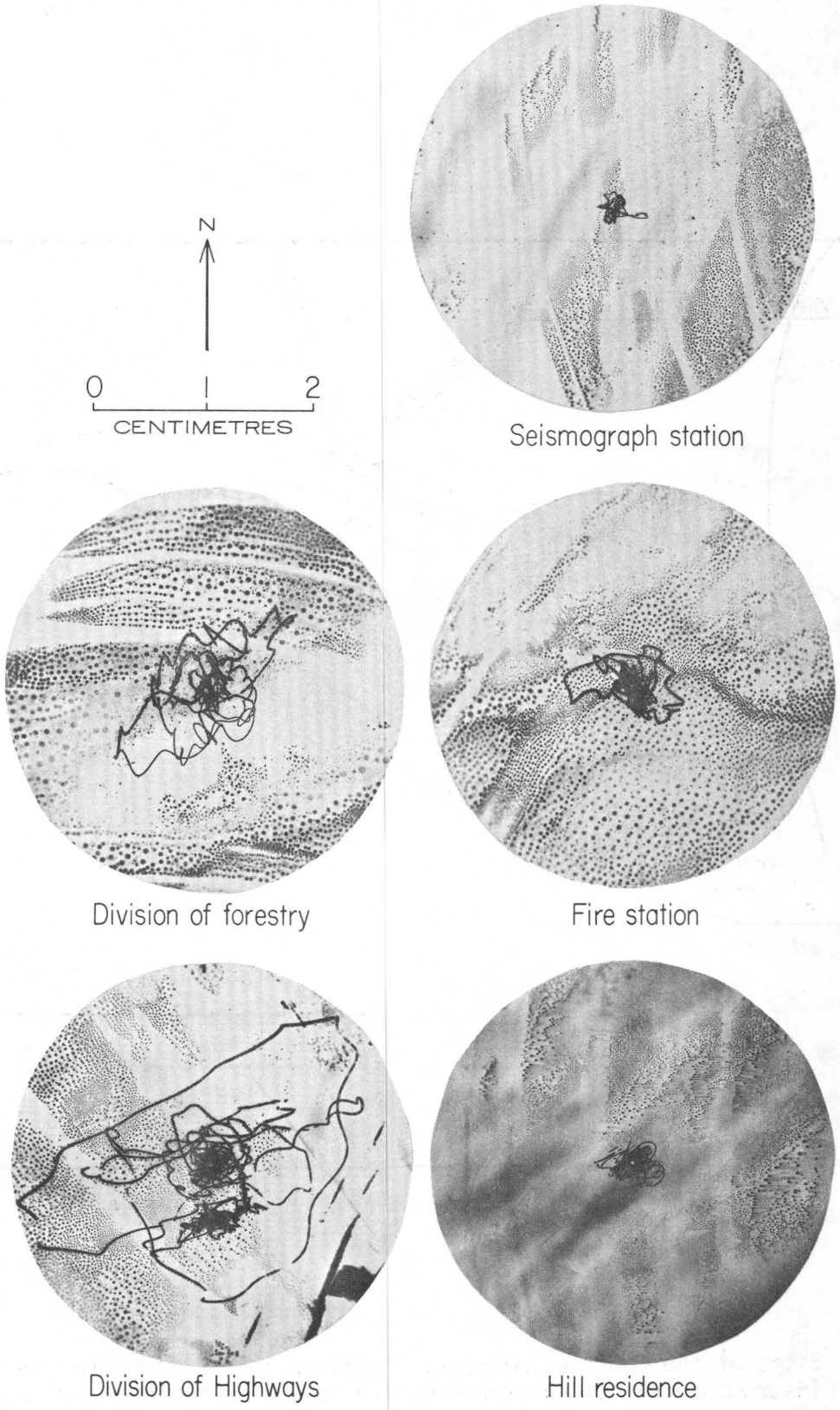

Figure 7. Copies of seismoscope records. Note the relatively large amplitudes exhibited by those records obtained farthest to the west.

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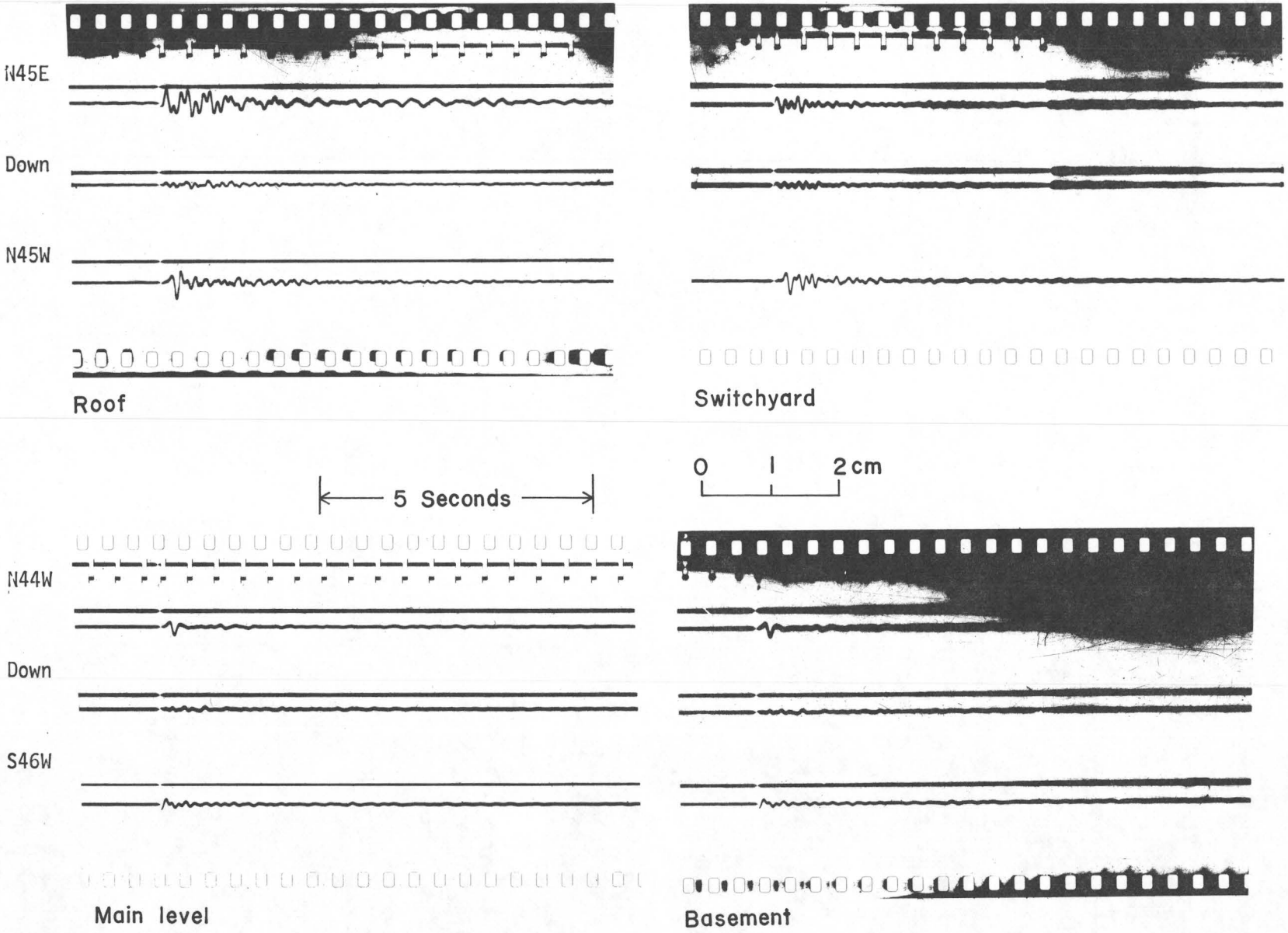

Figure 8. Accelerograph records from the Pleasant Valley Pumping Plant during the earthquake of August 3, 1975.