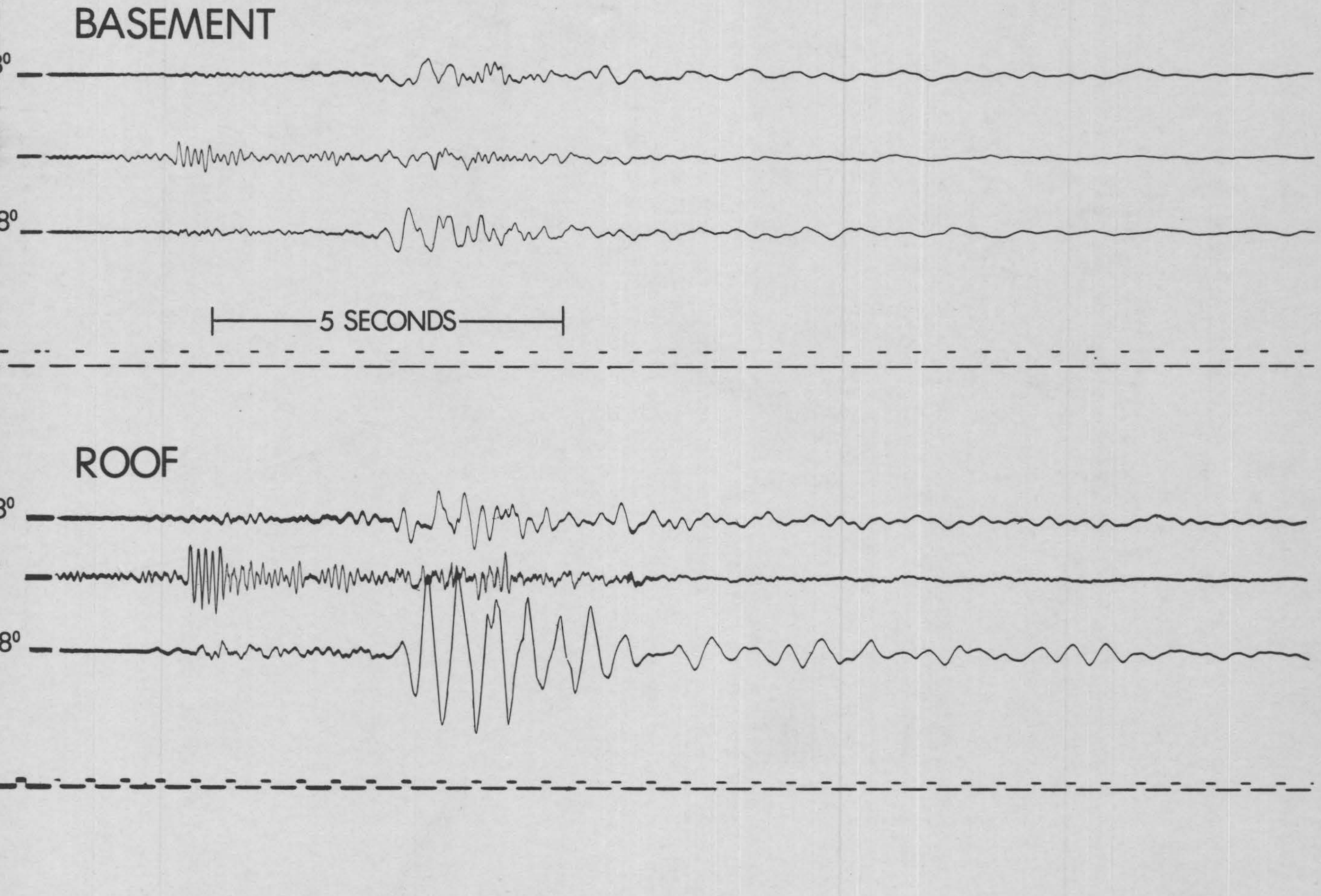
CIRC 854-A

Seismic Engineering Program Report January - April 1980

Prepared on behalf of the National Science Foundation Grant CA-114

LIVERMORE VA HOSPITAL

EARTHQUAKE OF JANUARY 24
Magnitude 5.5



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GEOLOGICAL SURVEY CIRCULAR 854-A

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1982

United States Department of the Interior
JAMES G. WATT, *Secretary*

Geological Survey
Dallas L. Peck, *Director*

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PREFACE

This Seismic Engineering Program Report is an informal periodical primarily intended to keep the ever-growing international community of strong-motion data users apprised of the nature and availability of data recovered by the Seismic Engineering Branch of the U.S. Geological Survey (USGS). This Strong-Motion Program is administered by the USGS and supported by the National Science Foundation (Grant CA-114) in cooperation with numerous Federal, State, and local agencies and organizations. Major objectives of the program include recording both strong ground motion and the response of various types of engineered structures during potentially damaging earthquakes and disseminating this strong-motion information and data to the earthquake engineering research and design community.

This issue contains a summary of the accelerograms recovered from the USGS National Strong-Motion Network during the period January 1 through April 30, 1980. Reproductions of some of the significant accelerograms from the Livermore Valley earthquakes of January 24 and 26 and the southern California (Horse Canyon) earthquake of February 25 are included along with summaries of recent strong-motion reports, notes on the availability of digitized data, and additional general information pertinent to the USGS and to other strong-motion programs. The data summary included in table 1 contains information on those accelerograms recovered (although not necessarily recorded) during the period January-April 1980; this procedure has been adopted so that the dissemination of strong-motion information may be as expeditious and current as practicable.

Ronald L. Porcella, Editor
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Seismic Engineering Program Report
January - April 1980

RECENT STRONG-MOTION RECORDS

by R. L. Porcella and J. C. Switzer

Eighty-one strong-motion records were recovered from the U.S. Geological Survey's National Strong-Motion Network during the period January 1 through April 30, 1980. These records are related to California earthquakes near Livermore in January, south of Anza on February 25, in the Imperial Valley for at least seven events, and throughout the remainder of the state for numerous other events (see table 1, end of report).

A magnitude 5.5 earthquake near Livermore on January 24 activated USGS accelerograph stations at the Livermore VA Hospital and at the California Department of Water Resources Del Valle Dam (fig. 1). Records from the VA Hospital show peak accelerations of 0.18 *g* and 0.59 *g* at the basement and roof (7th) levels, respectively. The maximum acceleration recorded at Del Valle Dam was 0.24 *g* at both the crest and toe stations; the duration of strong shaking (greater than 0.1 *g*), however, was more than three times longer at the crest site (fig. 2).

More than 500 aftershocks were recorded on seismographs during the following 30 days

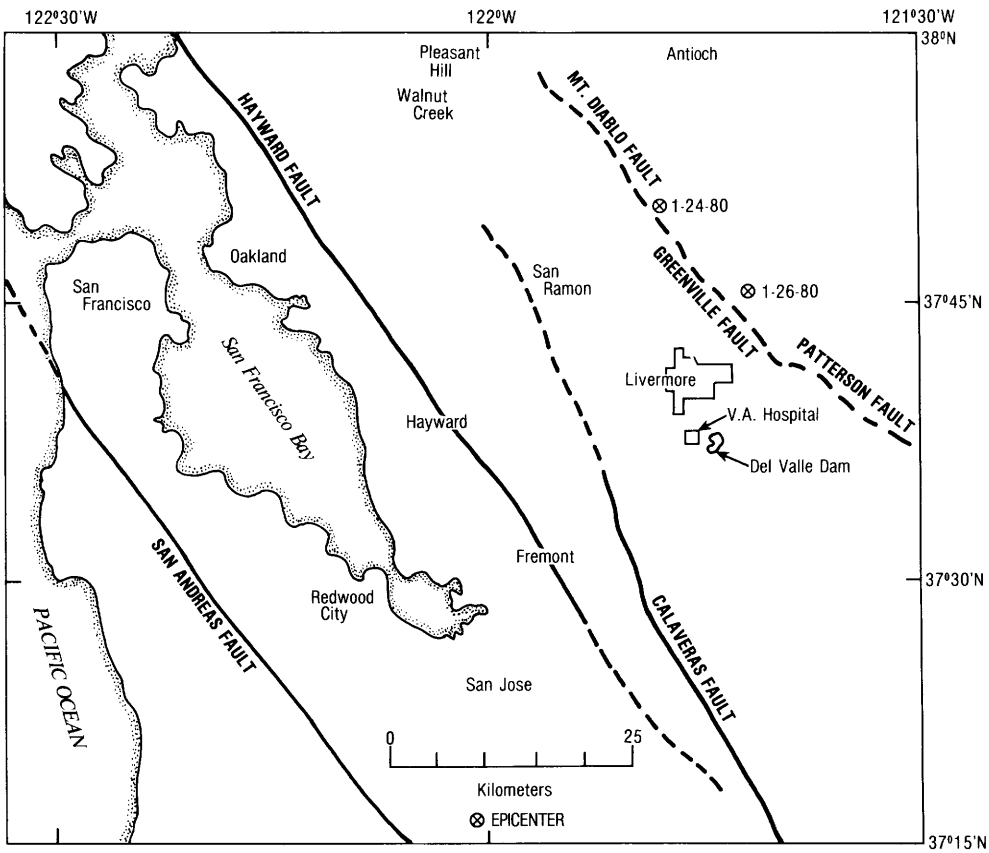

Figure 1 - Location map for Livermore earthquakes of January 24 and 26, 1980; fault locations (from Rogers, 1966) are approximate.

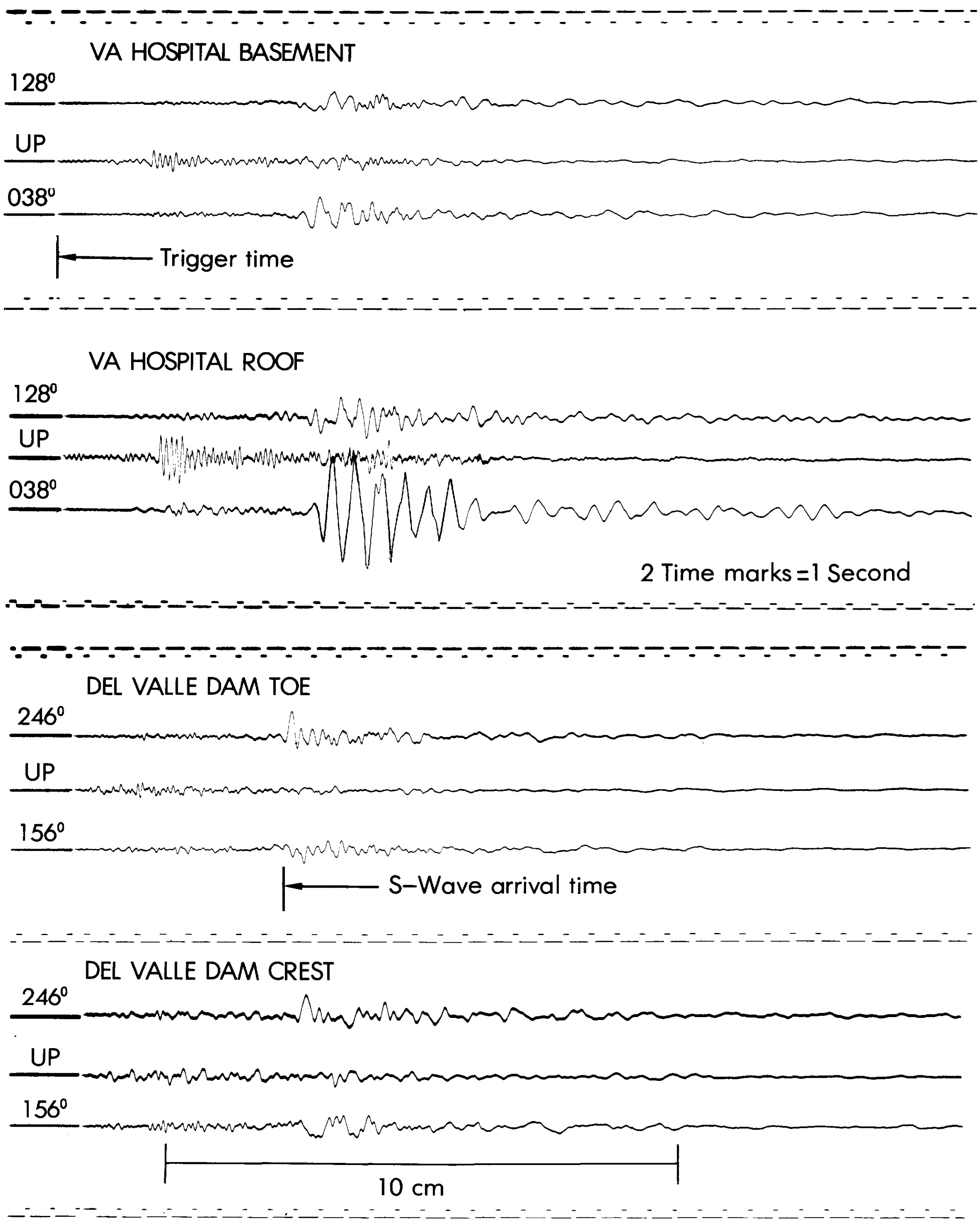

Figure 2 - Accelerograms from the January 24, 1980 Livermore, California earthquake; component label indicates direction of ground acceleration for upward trace deflection on accelerogram. See table 1 for peak acceleration values.

(Cockerham and others, 1980), including a magnitude 5.8 event on January 26 (January 27, 0233 UTC) that also triggered the accelerographs at the VA Hospital and at Del Valle Dam. Peak accelerations from this large aftershock, which occurred approximately 10 km southeast of the mainshock epicenter, were 0.06 _g_ and 0.24 _g_ at the hospital basement and roof levels, respectively. The accelerographs at Del Valle Dam recorded peak accelerations of 0.06 _g_ at the toe station and 0.07 _g_ on the crest (fig. 3).

Although the January 26 aftershock has been given a higher local magnitude rating and was located approximately 10 km closer to the VA Hospital and Del Valle Dam stations than the main shock, the recorded peak accelerations for the aftershock are only 0.25-0.33 as high as the main-shock accelerations.

In addition, 21 strong-motion records from each of the two Livermore events were recovered from stations operated by the California Division of Mines and Geology's Office of Strong-Motion Studies (OSMS). Peak horizontal ground accelerations from these stations were generally larger for the January 26 aftershock than for the main shock (McJunkin and Ragsdale, 1980; also, see fig. 1 and table 2).

These apparent inconsistencies in the peak acceleration data suggest that a consideration of magnitude and distance alone may not always be sufficient for predicting peak ground acceleration. This data set, which contains numerous accelerograms from both the January 24 main shock and January 26 aftershock that were recorded at the same sites, was used by Boore and Porcella (1980) to show that peak acceleration levels can have a strong dependence on azimuth and may be interpreted as a result of directivity.

The February 25, magnitude 5.5 earthquake near Anza in southern California triggered 16 accelerographs at USGS strong-motion stations; peak horizontal ground acceleration exceeded 0.05 _g_ at eight stations (see table 1 and fig. 4). Additionally, 25 accelerographs operated by the California Division of Mines and Geology's OSMS were triggered by this event; these stations are within an epicentral distance of 25-105 km and produced a maximum horizontal ground acceleration of 0.18 _g_ at Puerta La Cruz (R. D. McJunkin, written commun., March 1980).

References:

Boore, D. M., and Porcella, R. L., 1980, Peak acceleration from strong-motion records: a postscript: Seismological Society of America Bulletin, v. 70, no. 6, p. 2295-2297.

Cockerham, R. S., Lester, F. W., and Ellsworth, W. L., 1980, A preliminary report on the Livermore Valley earthquake sequence January 24 - February 26, 1980: U.S. Geological Survey Open-File Report 80-714, 54 p.

McJunkin, R. D., and Ragsdale, J. T., 1980, Strong-motion records from the Livermore earthquakes of 24 and 26 January 1980: California Division of Mines and Geology Preliminary Report 28, 91 p.

Rogers, T. H., 1966, Geologic map of California, San Jose sheet: California Division of Mines and Geology, scale 1:250,000.

Table 2 - Strong-motion stations (epicentral distance less than 50 km) that recorded both the January 24 and January 26 Livermore earthquakes (CDMG station data from McJunkin and Ragsdale, 1980)

Station (owner/code)	January 24 Magnitude 5.5		January 26 Magnitude 5.8	
	Epic. dist.[1] (km)	Horiz. PGA[2] (g)	Epic. dist.[3] (km)	Horiz. PGA (g)
San Ramon (CDMG/187)	17	0.15	21	0.28
San Ramon (CDMG/134)	17	.05	25	.05
Antioch (CDMG/70)	20	.04	30	.11
Walnut Creek (CDMG/364)	24	.03	36	.06
VA Hospital, Bsmt (USGS/1226)	24	.18	16	.06
Del Valle Dam, Toe (USGS/1265)	25	.24	16	.06
Pleasant Hill (CDMG/348)	26	.03	38	.06
Hayward (CDMG/354)	30	.04	38	.06
Hayward (CDMG/219)	30	.08	38	.08
Oakland (CDMG/225)	33	.02	40	.02
Fremont (CDMG/64)	36	.06	32	.11
Oakland (CDMG/359)	37	.02	47	.02

[1] Epicenter located at 37.84° N, 121.80° W.

[2] Peak ground acceleration.

[3] Epicenter located at 37.76° N, 121.70° W.

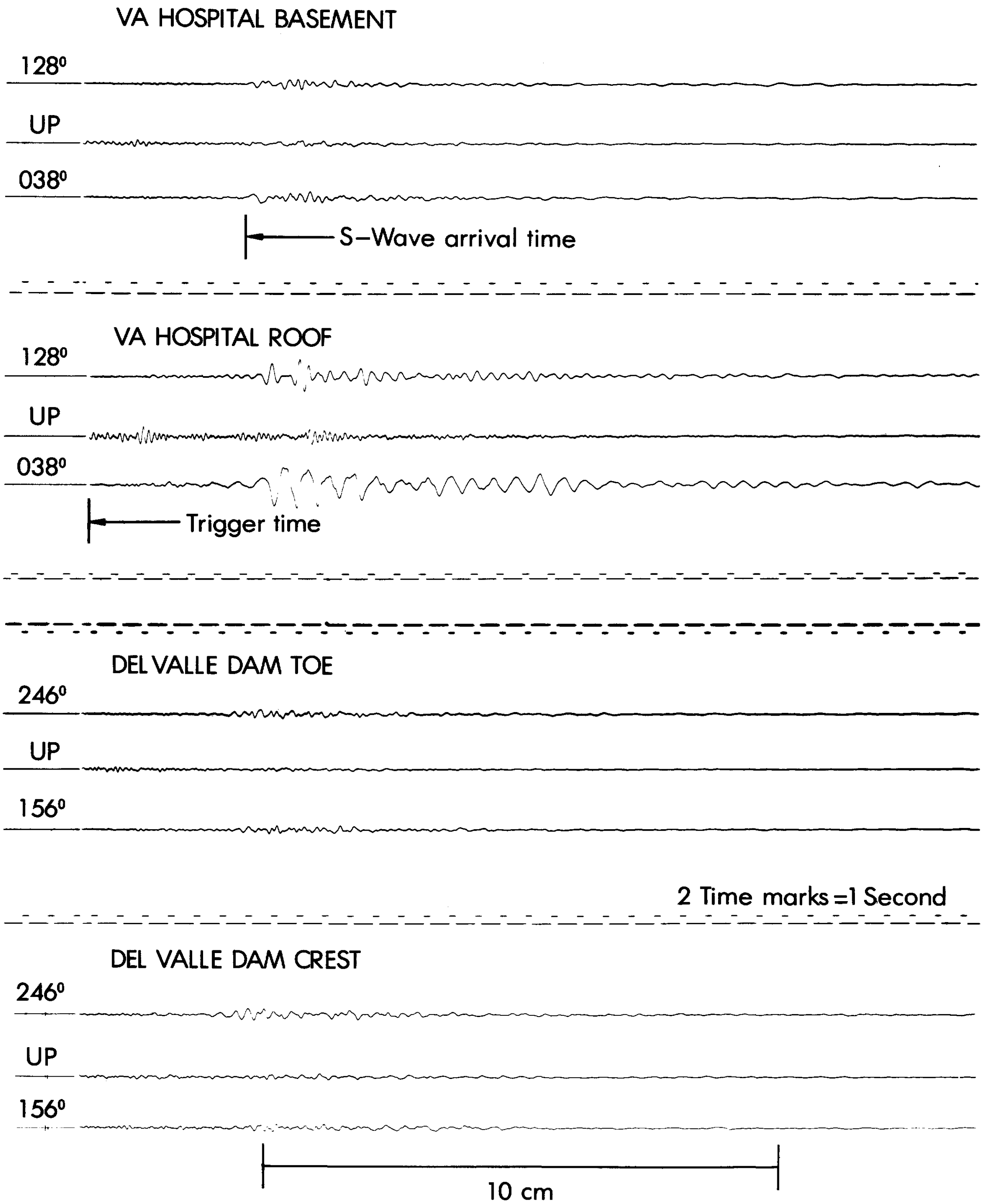

Figure 3 - Accelerograms from the January 26, 1980 Livermore aftershock; peak accelerations are listed in table 1.

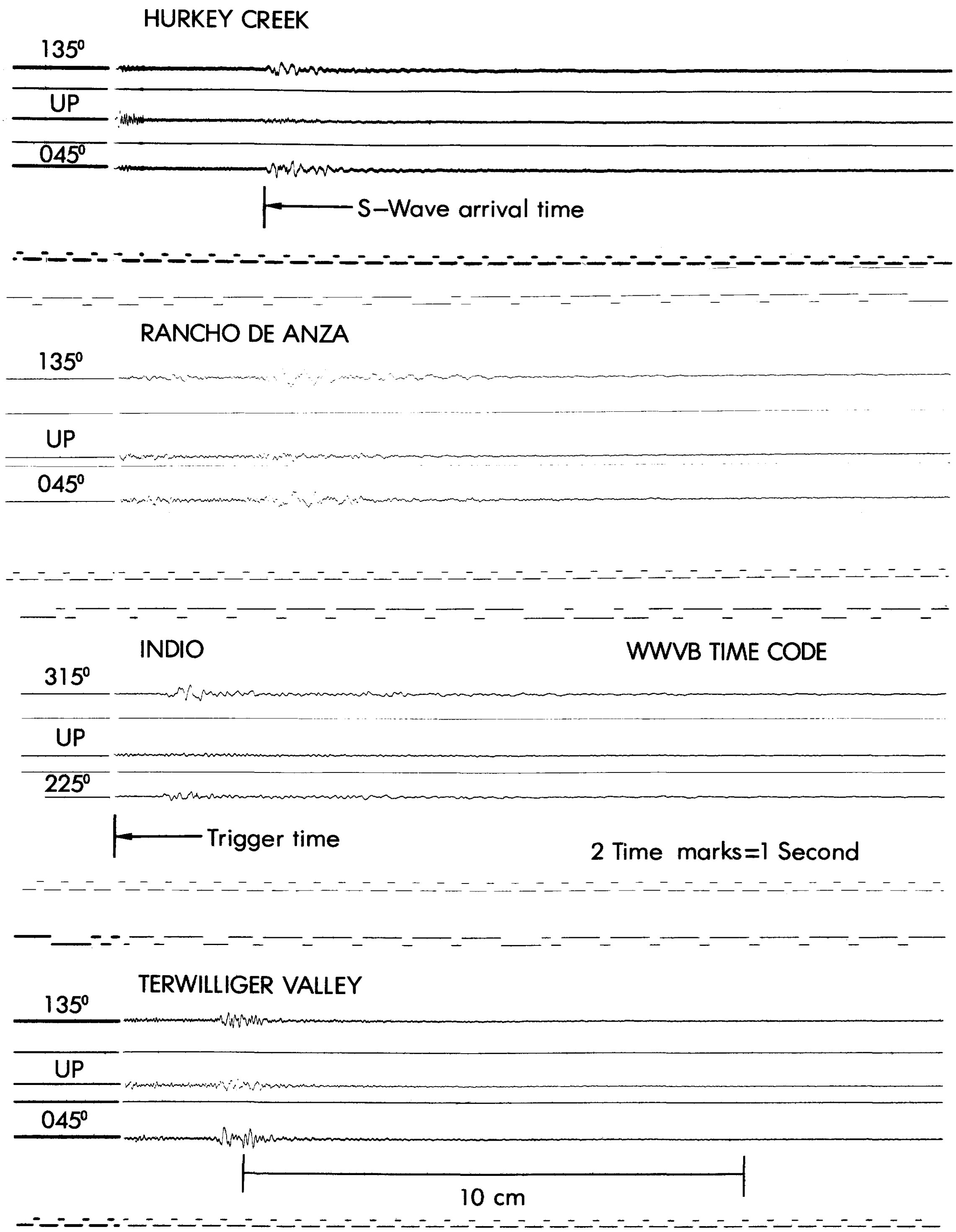

Figure 4 - Accelerograms from the February 25, 1980 Anza, California earthquake; peak accelerations are listed in table 1.

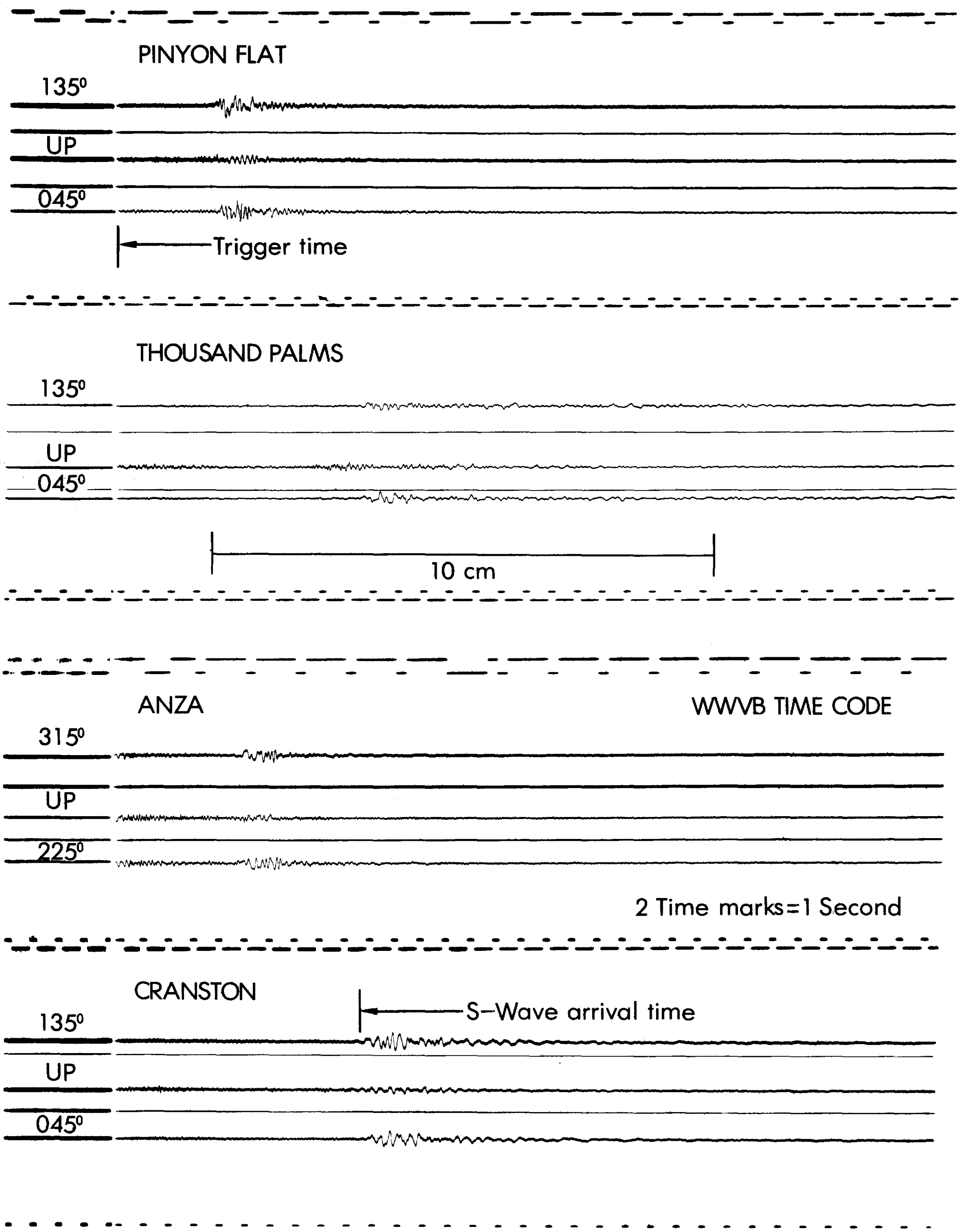

Figure 4 - continued.

SUMMARY OF RECENT EFFECTIVENESS IN MAINTENANCE OF THE USGS STRONG-MOTION NETWORK

Several years ago, operators of the USGS Strong-Motion Network decided to set as a goal for the field program keeping the strong-motion instrumentation 95 percent operational. At that time past records and the infrequency of maintenance may have made this goal seem unrealistic. However, numerous design changes have increased the reliability of existing and new instrumentation. As a result, not only has the goal been generally met, but the maintenance interval has been lengthened from four to six months and, in several test cases, to one year.

A periodic review of the installation and maintenance program is conducted in order to assess the progress in terms of general maintenance and to uncover specific problems in both reliability and accuracy. Table 3 shows the results of a 1980 review of 290 three-channel, optical-mechanical film recorders, of which approximately 75 percent are SMA-1, 22 percent are RFT-250, and 3 percent are TTA-350 accelerographs. The statistics were gathered from four different maintenance routes and three earthquake record-recovery trips and involved the efforts of six USGS technicians. Some differences in USGS operation and maintenance procedures from recommended manufacturer procedures include the following: 1) all instruments have Globe battery chargers, rather than the factory-supplied units, 2) all triggers are vertical, and 3) a single external high-capacity battery powers the instrument in preference to the lower capacity internal batteries supplied by the manufacturer. The maintenance interval is generally about 6 months, except after a significant earthquake or in special instances where cost factors require a longer maintenance interval.

Note that these figures and comments refer only to three-channel film recorders and do not include digital units, film recorders with remotely located transducers, or WWVB radio receivers installed on many of the SMA accelerographs. This high operational rate suggests that longer maintenance intervals, perhaps eight to nine months except in special circumstances, may be desirable.

Table 3 - 1980 review of USGS strong-motion network operational efficiency

Region/event	Inspections	Failures	Cause
New England	39	2	AC power out, film out
Oregon	32	3	Short, corrosion, take-up (TTA)
Hawaii	17	0	----
Mountain States	44	1	Relay failure (SMA)
Eastern California, Nevada	22	0	----
Gilroy, Calif. earthquake, 1979	70	1	Take-up (SMA)
Imperial Valley, Calif. earthquake, 1979	38	1	Take-up (RFT)
Mammoth Lakes, Calif. earthquakes, 1980	28	1	Take-up (RFT)
Total	290	9	97 percent operational

SUMMARIES OF RECENT STRONG-MOTION REPORTS★

STRONG-MOTION ACCELEROGRAMS OF THE OROVILLE, CALIFORNIA, AFTERSHOCKS: DATA PROCESSING AND THE AFTERSHOCK OF 0350 AUGUST 6, 1975

by Jon B. Fletcher, A. Gerald Brady, and Thomas C. Hanks

The Oroville aftershock accelerograms are characterized by short durations ($\lesssim 2$ s) of strong ground motion, small S-wave minus trigger times ($\lesssim 2$ s), and an enrichment in frequencies above 1 Hz, as might be expected for $3 \lesssim M \lesssim 5$ earthquakes recorded at close distances ($\bar{R} \lesssim 15$ km). These characteristics introduce significant error into the velocity and displacement traces calculated according to the routine procedures used in the series "Strong Motion Earthquake Accelerograms." These errors are markedly reduced by removing all decimation in the processing scheme and by constructing a smoother response for the Ormsby high-pass filter. The result is an accurate set of velocity and displacement traces that can be used in a wide variety of source-mechanism and ground-motion studies. These revised processing procedures are applied to the 10 strong-motion accelerograms of one of the largest aftershocks (0350 August 6 1975; $M_L = 4.7$) to illustrate the quality of data available for 12 such well-recorded aftershocks and to estimate the source properties of this particular earthquake. All of the accelerographs triggered on the P wave, allowing the recovery of the complete S wave on 10 accelerograms. Offsets in displacement across the S wave and a ramplike signature leading up to the S wave identified on the displacement traces are apparently near-field source effects. The seismic moment and stress drop determined for this normal faulting event are 4.0×10^{23} dyne-cm, and 410 bars, respectively. The seismic moment and stress drop are determined by averaging individual measurements at 9 and 8 stations, respectively, and are well constrained with standard deviations that are about 25 percent of the mean.

Reference: Bulletin of the Seismological Society of America, v. 70, no. 1, p. 243-267.

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* Inclusion of strong-motion information sources is intended as a service to our readers and does not imply endorsement of these reports by the U.S. Geological Survey.

THE ROLE OF ANELASTICITY IN EARTHQUAKE GROUND MOTION

by T. V. McEvilly and L. R. Johnson

A vertical seismic array at the Richmond Field Station has provided some excellent experimental data showing the effects of unconsolidated sediments on ground motion during local earthquakes. The experiments are well controlled in that good estimates of the material properties of the sediments are available; the largest uncertainty is in the attenuation. Three components of acceleration have been recorded in bedrock below the sediments, within the sediments, and at the surface of the sediments from two local earthquakes. The maximum accelerations at the surface are between 1.5 and 4.3 times those in the bedrock.

Analytical calculations that assume vertically propagating waves and that are suitable for highly attenuating materials predict reasonably well the differences between the bedrock records and the surface records for both vertical and horizontal components. Maximum accelerations, duration, frequency content, general character of the records, and response spectra are all in agreement. Some of the energy arriving late in the records can best be explained by surface waves propagating horizontally in the sediments.

Reference: U.S. Geological Survey Open-File Report 80-912, 37 p.

SPECTRA OF AMPLITUDES SUSTAINED FOR A GIVEN NUMBER OF CYCLES: AN INTERPRETATION OF THE RESPONSE DURATION FOR STRONG-MOTION EARTHQUAKE RECORDS

by Virgilio Perez

To answer the question, "What response amplitude is sustained for a duration equal to a specified number of cycles?", a technique was developed using the response of a single-degree-of-freedom, lightly damped oscillator to generate a spectrum of amplitudes that corresponds to a specific number of cycles. This technique provides a simple approach by which to compare the amplitude sustained for given numbers of cycles as a percentage of the maximum response.

The response as a function of time may consist of one or a very few oscillations of high amplitude followed by many oscillations of lower amplitude. An "effective response" defined in terms of the amplitude sustained for a chosen number of cycles might indicate the severity of the response to a particular earthquake. Preliminary analyses of 12 accelerograms indicate that for oscillators with 5 percent damping and with periods in the range 0.04 to 4 seconds, the mean "effective response" for four cycles lies between 52 to 76 percent of maximum response.

Reference: Bulletin of the Seismological Society of America, v. 70, no. 5, p. 1943-1954.

EL CENTRO, CALIFORNIA DIFFERENTIAL GROUND MOTION ARRAY

by G. Noel Bycroft

Differential ground motions due to horizontally propagating seismic surface waves are important in determining the stresses developed in extended structures such as large mat foundations for nuclear power stations, dams, bridges, and pipelines. This report discusses the design of an array to measure these differential ground motions and describes one such array recently installed at El Centro, Calif. The records from the October 15, 1979 Imperial Valley earthquake are presented.

Reference: U.S. Geological Survey Open-File Report 80-919, 15 p.

OCTOBER 15, 1979 MAINSHOCK STRONG-MOTION RECORDS FROM THE MELOLAND ROAD-INTERSTATE ROUTE 8 OVERCROSSING, IMPERIAL COUNTY, CALIFORNIA

by Christopher Rojahn, J. T. Ragsdale, J. D. Raggett, and J. H. Gates

At the time of the October 15, 1979 earthquake, the Meloland Road-Interstate Route 8 overcrossing, a continuous two-span reinforced-concrete bridge 0.5 km southwest of the Imperial fault, was instrumented with two 13-channel remote-accelerometer central-recording accelerograph systems. Although the film transport in one of the two recorders malfunctioned during the earthquake, these instruments provided an important and usable data set. Peak accelerations in the north-south, vertical, and east-west directions at the base of the bridge's central support column were 0.28, 0.17, and 0.33 g, respectively, whereas those at an adjacent free-field site were 0.32, 0.23, and 0.30 g, respectively. Peak accelerations recorded on embankment sites adjacent to each abutment were substantially higher than those recorded at the base of the bridge's central support column; these data suggest that the structure itself altered the motion at the embankment sites. Other important features of the records include (1) an acceleration pulse 1 s long occurring in the east-west components at the free-field, column base, and embankment sites, and (2) strong evidence of modal response of the bridge during and after the period of strongest ground shaking. The bridge did not sustain any significant structural damage during the earthquake.

Reference: U.S. Geological Survey Open-File Report 80-1054, 14 p.

SELECTED PAPERS ON THE IMPERIAL VALLEY, CALIFORNIA, EARTHQUAKE OF OCTOBER 15, 1979

by Christopher Rojahn (Editor)

On October 15, 1979, the largest earthquake in California in the past quarter century occurred on the Imperial fault near the International Boundary between the United States and Mexico. The magnitude 6.6 (M_L) earthquake was felt from Las Vegas, Nev. to northern Mexico, was accompanied by surface movement on four fault zones, and caused approximately $30 million damage. The earthquake generated the most comprehensive set of data on ground shaking yet recorded from a damaging earthquake anywhere in the world and is the first damaging earthquake in California's history for which the actual surface rupture zones had been defined by detailed fault mapping prior to the seismic event.

Included in this report are four selected papers on various topics relating to the October 15 earthquake. These papers include reports on the distribution of intensity, peak horizontal ground motion and a comparison with previous events, M_L and M_0 determinations from accelerograms, and a study of selected aftershocks using digital acceleration and velocity recordings.

Reference: U.S. Geological Survey Open-File Report 80-1094, 67 p.

AN ANALYSIS OF STRONG-MOTION DATA FROM A SEVERELY DAMAGED STRUCTURE, THE IMPERIAL COUNTY SERVICES BUILDING, EL CENTRO, CALIFORNIA

by Christopher Rojahn and P. N. Mork

The Imperial County Services Building, a six-story reinforced-concrete frame and shear-wall office building 7.6 km southwest of the Imperial fault trace in El Centro, Calif., sustained significant structural damage during the October 15, 1979 earthquake. Strong-motion instrumentation at the site, installed and maintained by the California Division of Mines and Geology, consists of a 13-channel remote-accelerometer central-recording accelerograph system in the building and a triaxial accelerograph located at ground level approximately 100 m to the east. Several features of the main-shock accelerogram recovered from the building, including abrupt changes in frequency content and bursts of high-frequency motion, provide important information on the mechanism of structural failure. A comparison of the main-shock motions recorded at the base of the building with those recorded at the adjacent ground site (intended to be free field) indicates that the motion recorded at the ground floor of the building incorporates to a significant extent the response of the building-soil-foundation system. The acceleration data also show that the building's fundamental periods changed significantly during the earthquake. A preliminary relative-displacement analysis indicates that the east-west interstory displacement between the second and ground floors was approximately 6.2 cm at the beginning of column collapse.

Reference: U.S. Geological Survey Open-File Report 81-194, 48 p.

PEAK HORIZONTAL ACCELERATION AND VELOCITY FROM STRONG-MOTION RECORDS INCLUDING RECORDS FROM THE 1979 IMPERIAL VALLEY, CALIFORNIA, EARTHQUAKE

by William B. Joyner, David M. Boore, and Ronald L. Porcella

We have taken advantage of the recent increase in strong-motion data at close distances to derive new attenuation relations for peak horizontal acceleration and velocity. Acceleration data from 183 recordings of 24 earthquakes and velocity data from 62 recordings of 10 earthquakes have been used. This new analysis uses a magnitude-independent shape for the attenuation curve based on geometrical spreading and anelastic attenuation. A magnitude-dependent shape could be accommodated by the method, but the data do not support it. An innovation in technique is introduced that decouples the determination of the distance dependence of the data from the magnitude dependence. The resulting equations are

$$\log A = -1.23 + 0.280\,M - \log r - 0.00255r + 0.27P$$

$$r = (d^2 + 7.3^2)^{1/2} \quad 5.0 \leq M \leq 7.7$$

$$\log V = -1.30 + 0.581\,M - \log r - 0.00256r + 0.17S + 0.35P$$

$$r = (d^2 + 4.0^2)^{1/2} \quad 5.3 \leq M \leq 7.4$$

where A is peak horizontal acceleration in g, V is peak horizontal velocity in cm/s, M is moment magnitude, d is the closest distance to the surface projection of the fault repture in km, and P is zero for 50 percent exceedance probability and one for 84 percent.

Reference: U.S. Geological Survey Open-File Report 81-365, 46 p.

STRONG-MOTION RECORDS FROM THE LIVERMORE EARTHQUAKES OF JANUARY 24 AND 26, 1980

by R. D. McJunkin and J. T. Ragsdale

This report summarizes California Division of Mines and Geology Strong-Motion Instrumentation Program (CSMIP) accelerograph records recovered from the January 24 and 26, 1980 Livermore earthquakes. All CSMIP accelerograph stations that were triggered by the earthquakes are listed, together with their respective ground accelerations and other pertinent earthquake data, and are arranged in order of increasing epicentral distance. Response data for structures instrumented by CSMIP are also presented. All records from CSMIP stations recording 0.05 g or greater ground acceleration are determined to be significant and are reviewed in detail. Earthquake records from the Livermore events will eventually be digitized and processed and made available in a CSMIP special publication.

Reference: California Division of Mines and Geology Preliminary Report 28, 91 p.

STRONG-MOTION INFORMATION, DATA REPORTS, AND AVAILABILITY OF DIGITIZED DATA

U.S. STRONG-MOTION NETWORK DATA

A strong-motion information retrieval system (SMIRS) has been developed to provide up-to-date information about strong-motion records and the circumstances in which they were recorded. The system is accessible through a data terminal (30 cps, half duplex). The system is operational, but the information within it is incomplete and needs to be verified. A user's manual is available (Converse, 1978). To retrieve information, dial (415) 329-8600 and place the telephone handset into the terminal. When the carrier light comes on, press the "line-feed" key and wait for the computer to respond (two lines will be printed); type the following:

enter yourname SMIRS

Type the "enter" and "SMIRS" exactly as shown above, but replace yourname with your own name. The word "enter" is five lowercase characters followed by one space; your name is typed as one continuous character string and followed by one space; and "SMIRS" is five uppercase characters. Type the carriage-return key and then the line-feed key; then you will be given instructions.

The strong-motion records from the February 9, 1971 San Fernando, California, earthquake and most of the significant records prior to that event have been digitized by the California Institute of Technology (CIT) (Hudson, 1976). Processing and analysis of the data have been presented in a series of reports containing (1) uncorrected digital data, (2) corrected accelerations, velocities, and displacements, (3) response spectra, and (4) Fourier amplitude spectra. All of these data reports are available through the National Technical Information Service (NTIS, see Data Sources, this report).

The digitization and analysis of the records collected by the State of California Strong-Motion Instrumentation Program are being handled by the Office of Strong-Motion Studies (OSMS), California Division of Mines and Geology. When completed, reports on these analyses will be available from OSMS (see Data Sources, this report).

The digitized data from the CIT digitization program are available from the Environmental Data and Information Service (EDIS) and the National Information Service for Earthquake Engineering at the University of California, Berkeley (NISEE) (see Data Sources, this report). The magnetic tape digital data from subsequent years will be available from EDIS and NISEE at approximately the same time as the data reports are published.

References:

Converse, April, 1978, Strong-motion information retrieval system user's manual: U.S. Geological Survey Open-File Report, 79-289, 51 p.

Hudson, D. E., 1976, Strong-motion earthquake accelerograms - index volume: California Institute of Technology, EERI report 76-02, 72 p.

CALIFORNIA DIVISION OF MINES AND GEOLOGY STRONG-MOTION DATA

Processed strong-motion data from selected earthquakes are available from the California Division of Mines and Geology. The data have been prepared by the interim CDMG strong-motion data processing system. This system is composed of a series of programs that have been developed by the California Institute of Technology, the U.S. Geological Survey, and the California Division of Mines and Geology, with special emphasis on the handling of long-duration film records from multiple-channel central recording instruments.

The data are grouped by phase:

Phase I	Uncorrected accelerations,
Phase II	Corrected accelerations, velocities, and displacements,
Phase III	Response spectra.

Each phase contains three-channel subgroups arranged by station. At the present time, data from the following earthquakes have been processed:

Santa Barbara earthquake of August 13, 1978

Station	Channels
UCSB Goleta	3
UCSB North Hall	9
Freitas Building	9

Imperial Valley earthquake of October 15, 1979

Station	Channels
El Centro free-field	3
Imperial County Services Bldg.	13

The data are available on standard nine-track tapes, along with a microfiche copy of the tape contents. Interested parties should contact the CDMG Office of Strong-Motion Studies (see Data Sources, this report).

It is the policy of the CDMG to make all strong-motion record data promptly available to the public in a manner consistent with good data management. Requests for copies of records, personal access to record or data files, and copies of data files should be made to the Chief, Office of Strong-Motion Studies(OSMS), and should specify identity and medium of materials to be provided or reviewed. Desired access or delivery dates should be specific. When a request for copies of materials or personal access to files is received, OSMS staff will provide the requested material or will set an appointment time for personal review of files; the requestor will be notified immediately of any significant delay or other problems that prevent meeting the request. Charges for copying or other processing of materials will be based on the actual cost of producing and delivering the items, and OSMS will retain control of originals and master copies of all items.

FOREIGN STRONG-MOTION DATA

Because of the long history of close cooperation between the U.S. and the Central and South American strong-motion programs, much of the data from those programs are available from the same sources as the U.S. data (see below). Information about strong-motion data from the Western Hemisphere will be included in the Strong-Motion Information Retrieval System operated by the USGS.

EDIS/NOAA WORLDWIDE STRONG-MOTION DATA

A worldwide collection of strong-motion seismograms for dissemination to the scientific and engineering community is available from World Data Center A for Solid Earth Geophysics and the National Geophysical and Solar-Terrestrial Data Center (NGSDC). Countries contributing to the strong-motion data base include Australia, Italy, Japan, New Zealand, Rumania, U.S.S.R., and Yugoslavia. The U.S. Geological Survey has furnished records from its network of cooperative strong-motion stations, including those in Central and South America.

Copies of strong-motion records are available on 35-mm film, on 70-mm film chips, as paper copies, and as digitized data on punched cards or magnetic tape. A list of most records can be obtained from the World Data Center A publication "Catalog of Seismograms and Strong-Motion Records, Report SE-6." This catalog can be ordered from NGSDC (EDIS/NOAA) for $2.00 (see Data Sources, this report).

The most significant strong-motion records recorded in the United States and Latin America between 1931 and 1971 have been copied on eight reels of 35-mm film (12x reduction) and 70-mm film chips (approximately 8x reduction). The film chips are available for $.50 per chip; longer records are continued on additional chips. The 35-mm film copies can be purchased for $20 per reel, the complete set of reels for $130.

Full-size paper copies (12 x 36 inches) are available for many of the events in the United States and Latin America at a cost of $1.50 per record. Other records are available as paper copies, but at a reduced scale.

Japan and Australia have supplied magnetic tapes of digitized data from stations located in the western Pacific Ocean (the Japanese Islands, New Guinea, and New Britain). A series of 400 U.S. strong-motion records (1933-1971) were digitized by the California Institute of Technology and are now available on six magnetic tapes. The U.S. Geological Survey is digitizing post-1971 records from its network; they have generated five tapes of strong-motion records recorded from 1967 to 1975 in the United States, Chile, Nicaragua, San Salvador, and Mexico.

Other digitized data include punched cards containing strong-motion records from the March 4, 1977 earthquake in Rumania (recorded in Bucharest); the Gazli earthquake of May 17, 1976, in Uzbek, U.S.S.R.; and three earthquakes in the New Madrid seismic zone (located in midcontinental United States) in 1975 and 1976.

Recent acquisitions include a magnetic tape of strong-motion records triggered by a swarm of earthquakes that occurred in northern Italy near the town of Friuli in 1976; these were compiled by the National Commission for Nuclear Energy and have been given to the Center for distribution.

A table listing all digitized strong-motion records available on magnetic tape may be obtained free of charge from EDIS/NOAA. Digitized strong-motion records may be purchased either in punched card format at $20 per record (including all three instrument components) or in tape format at $60 per tape.

Checks or money orders should be made payable to "Commerce/NOAA/NGSDC"; inquiries should be addressed to EDIS/NOAA (see Data Sources, this report).

DATA SOURCES

For reports or information regarding strong-motion records and data, address inquiries to the appropriate agency listed below:

1. Branch of Distribution, U.S. Geological Survey, 604 S Pickett Street, Alexandria, VA 22304 — (804) 756-6141, (FTS) 756-6141
2. Earthquake Engineering Research Institute, 2620 Telegraph Avenue, Berkeley, CA 94704 — (415) 848-0972
3. EDIS/NOAA, National Geophysical and Solar-Terrestrial Data Center (D62), Boulder, CO 80302 — (303) 497-6764, (FTS) 320-6764
4. National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22151 — (703) 487-4650, (FTS) 737-4650
5. NISEE/Computer Applications, 519 Davis Hall, UC Berkeley, Berkeley, CA 94720. — (415) 642-5113
6. Office of Strong-Motion Studies, California Division of Mines and Geology, 2811 "O" Street, Sacramento, CA 95816 — (916) 322-3105, (FTS) 552-3105
7. Open-file Services Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225 — (303) 234-5888, (FTS) 234-5888
8. Seismic Engineering Branch, U.S. Geological Survey, 345 Middlefield Road, MS 78, Menlo Park, CA 94025. — (415) 323-8111 ext 2881, (FTS) 467-2881

ERRATA

Reference	Error	Correction
CIT; EERL S-M earthquake accelerograms, digitized & plotted data; vol II, III, IV; Part B; Record #037 (1966 Parkfield earthquake)	Temblor, Calif. No. 2 USGS Station No. 1097 35 45'07" N 120 15'52" W	Temblor, Calif. USGS Station No. 1438 35 42'36" N 120 10'12" W
same as above: vol I, II; Part C Record #041 (1971 San Fernando earthquake; Component direction- Pacoima Dam accelerogram)	L - S74W V - Down T - S16E	L - N76W V - Down T - S14W
USGS S-M Station No. 1250 Gilroy, Gavilan College (Component direction - all S-M records since Oct. 1972)	L - S67W V - Down T - S13E	L - S67W V - Down T - S23E
USGS S-M Station 2420 New Madrid, Missouri (Component direction- events of 6-13-75 and 3-24-76)	L - S19W V - Down T - S71E	L - West V - Down T - South
USGS S-M Station no. 181; Los Angeles, 640 Marengo, 1st floor (Component direction prior to 7-15-70)	L - N36W V - Down T - S54W	L - S54W V - Down T - S36E
NOTE: Since 7-15-70, the 1st floor (also 4th floor and roof) component directions are:		L - N36W V - Down T - S54W
USGS S-M Station No. 122; Glendale, California (Component direction - events of 4/8/68 and 2/9/71)	L - S70E V - Down T - S20W	L - S72E V - Down T - N18E
USGS S-M Station No. 125(828); Lake Hughes Array Station 1 (1A) Component direction:		
event 9/12/70	L - N21E V - Down T - N69W	L - S21W V - Down T - S69E
event 2/9/71	L - N21E V - Down T - S69E	L - S21W V - Down T - S69E

Table 1. - *Summary of accelerograms recovered during January - April 1980*

Event	Station name (owner)[1]	Station coord.		S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
20 October 1979 0625 UTC Central California 36.57N, 121.21W Magnitude 3.4	Bear Valley station 10 Webb Ranch (USGS)	36.53° 121.14°	N W	1.4		**	
	Note: One additional record recovered at station 10 (event unknown); maximum acceleration less than 0.05 g.						
	Bear Valley station 4 Bickmore Canyon (USGS)	36.57° 121.22°	N W	1.0		**	
4 November 1979 1713 UTC So. California 33.08N, 115.55W Magnitude 3.6	Brawley Municipal Airport (USGS)	32.988° 115.509°	N W	.8	315° Up 225°	0.13 .04 .13	1.2 - .8
21 October 1979- 4 January 1980 Central California Epicenters and magnitudes unknown	Bear Valley station 10 Webb Ranch (USGS)	36.53° 121.14°	N W	.8	310° Up 220°	.05 .05 .06	- - -
	Note: One additional record recovered at station 10; maximum acceleration less than 0.05 g.						
5 January 1980 2209 UTC Central California Epicenter and magnitude unknown	Bear Valley station 10 Webb Ranch (USGS)	36.53° 121.14°	N W	.7		**	
8 January 1980 1935 UTC Central California Epicenter and magnitude unknown	Bear Valley station 10 Webb Ranch (USGS)	36.53° 121.14°	N W	1.7		**	
12 January 1980 2011 UTC So. California 32.90N, 115.52W Magnitude 4.4	El Centro array sta. 5 James Road (USGS)	32.86° 115.47°	N W	2.6	230° Up 140°	.07 .04 .09	- - -
	Brawley Municipal Airport (USGS)	32.99° 115.51°	N W	-		**	
	El Centro array sta. 6 Huston Road (USGS)	32.84° 115.49°	N W	2.7		**	

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
13 January 1980 2113 UTC So. California 33.12N, 115.70W Magnitude 3.5	Calipatria Fire Station (USGS)	33.13° N 115.52° W	2.8		**	
13 January 1980- 26 February 1980 So. California Epicenter and magnitude unknown	Calipatria Fire Station (USGS)	33.13° N 115.52° W	3.5		**	
24 January 1980 1900 UTC Central California 37.85N, 121.82W Magnitude 5.5	Livermore VA Hospital, Bldg. 62 (VA)†	37.625° N 121.762° W	4.6			
	Basement			128° Up 038°	0.12 .12 .18	1-peak 4.2 1.6
	Roof level (7)			128° Up 038°	.22 .27 .59	1.7 4.6 6.6
	Del Valle Dam (CDWR)†	37.617° N 121.746° W	3.8			
	Toe			246° Up 156°	.24 .08 .14	.9 - 1-peak
	Crest			246° Up 156°	.24 .13 .13	2.8 2-peaks 1.4
27 January 1980 0233 UTC Central California 37.74N, 121.74W Magnitude 5.8	Del Valle Dam (CDWR)†	37.617° N 121.746° W	2.7			
	Toe			246° Up 156°	.05 .03 .06	- - -
	Crest			246° Up 156°	.07 .04 .05	- - -

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
27 January 1980 0233 UTC (continued)	Livermore VA Hospital, Bldg. 62 (VA)†	37.625° N 121.762° W	3.0			
	Basement			128°	0.05	-
				Up	.06	-
				038°	.06	-
	Roof level (7)			128°	.17	0.7
				Up	.10	.3
				038°	.24	3.4
	Note: Two each aftershock records were recovered at Livermore VA hospital (basement and roof) and Lawrence Livermore Lab (events between 28 January and 22 February); maximum acceleration less than 0.05 g.					
	San Francisco VA Hospital (USGS) †	37.78° N 122.50° W	-			
	Basement				**	
	7th floor				**	
	Alameda Fruitvale Ave. Bridge (ACOE) †	37.77° N 122.23° W	6.1		**	
9 August, 1979- 28 January 1980 Central California Epicenters and magnitudes unknown	Hayward City Hall (USGS)	37.68° N 122.08° W	1.0			
	6th floor				**	
	11th floor				**	
	Note: Three each additional records were recovered at the 6th and 11th floors; maximum acceleration less than 0.05 g.					
23 January 1980- 26 February 1980 So. California Epicenter and magnitude unknown	Brawley Municipal Airport (USGS)	32.99° N 115.51° W	1.9	315°	.11	1-peak
				Up	.03	-
				225°	.10	1-peak

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.		S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
25 February 1980 1047 UTC So. California 33.52N, 116.55W Magnitude 5.5	Fun Valley Reservoir 361 (USGS)	33.93° 116.40°	N W	.3		**	
	Cabazon Post Office (USGS)	33.92° 116.78°	N W	-		**	
	North Palm Springs Post Office (USGS)†	33.92° 116.54°	N W	5.8		**	
	Thousand Palms Post Office (USGS)†	33.82° 116.40°	N W	4.7	135° Up 045°	0.05 .05 .07	- - -
	Anza Fire Station (USGS)	33.75° 116.67°	N W	2.5	315° Up 225°	.07 .05 .07	- - -
	Indio So. Calif. Gas Co. (USGS)	33.75° 116.21°	N W	.9	315° Up 225°	.09 .03 .05	- - -
	Pinyon Flat Observ. Underground vault (USGS)	33.61° 116.46°	N W	1.8	135° Up 045°	.13 .07 .11	0.3 - 1-peak
	Rancho de Anza Anza-Borrego Park (USGS)	33.35° 116.40°	N W	2.8	135° Up 045°	.11 .05 .09	.8 - -
	Coachella Canal Station 1 (USGS)	33.64° 116.08°	N W	6.4		**	
	Borrego Air Ranch Borrego Springs (USGS)	33.19° 116.28°	N W	5.7		**	
	Terwilliger Valley Snodgrass Residence (USGS)	33.48° 116.59°	N W	1.8	135° Up 045°	.09 .06 .12	- - .6
	Morongo Valley F.S. Morongo Valley, Calif. (USGS)	34.05° 116.58°	N W	7.3		**	

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
25 February 1980 1047 UTC (continued)	Hurkey Creek Park (USGS)	33.67° N 116.68° W	3.1	135° Up 045°	0.08 .09 .11	- - 1-peak
	Cherry Valley (USGS)	33.98° N 116.99° W	8.5		**	
	Whitewater Trout Farm (USGS)	33.99° N 116.66° W	6.7		**	
	Cranston Forest Sta. (USGS)	33.74° N 116.84° W	4.7		.11 .04 .11	1-peak - 1-peak
27 February 1980 0129 UTC So. California 32.95N, 115.57W Magnitude 3.6	Brawley Municipal Airport (USGS)	32.99° N 115.51° W	2.8		**	
	Calipatria Fire Station (USGS)	33.10° N 115.52° W	-		**	
20 November 1979- 27 February 1980 So. California Epicenters and magnitudes unknown	Lake Mathews Dike toe (MWD)	33.85° N 117.45° W	-		**	
	Diemer Filter Plant (MWD)	33.91° N 117.82° W	.9		**	
	Hoover Dam (CDWR)	36.02° N 114.74° W	-			
	Intake tower				**	
	Gallery				**	
	Note: Four additional records from events during this time period recovered at gallery station; maximum acceleration less than 0.05 g.					
22 February 1980- 27 February 1980 Central California Epicenter and magnitude unknown	Livermore VA Hospital (VA)	37.625° N 121.762° W	-			
	Basement				**	
	Roof				**	
	Note: May be related to earthquake of 22 February (2226 UTC).					

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
17 August 1979- 5 March 1980 Central California Epicenters and magnitudes unknown	Bear Valley station 9 Schroll Ranch (USGS)	36.63° N 121.28° W	1.5		**	
	Note: One additional record recovered at station 9; maximum acceleration less than 0.05 g.					
6 March 1980 1105 UTC Central California 36.67N, 121.37W Magnitude 4.0	Bear Valley station 12 Williams Ranch (USGS)	36.66° N 121.25° W	2.1		**	
	Note: One aftershock recorded at station 12 on 6 March (1108 UTC); maximum acceleration less than 0.05 g.					
	Bear Valley station 9 Schroll Ranch (USGS)	36.63° N 121.28° W	1.2		**	
28 March 1980 2201 UTC Imperial Valley Epicenter and magnitude unknown	Calipatria Fire Station (USGS)	33.13° N 115.52° W	1.6		**	
1 January 1980- 3 April 1980 So. California Epicenters and magnitudes unknown	Parachute Test Site Imler Road (USGS)	32.93° N 115.70° W	1.3		**	
	Note: One additional record recovered at Parachute Test Site; maximum acceleration less than .05 g.					
	El Centro array sta. 9 Commercial Ave. (USGS)	32.79° N 115.55° W	-		**	
9 October 1979- 11 April 1980 So. California Epicenter and magnitude unknown	Escondido Power Station (SDGE)	33.125° N 117.117° W	-	030° Up 300°	0.04 .04 .14	- - 0.3
	May be related to earthquake of 25 February 1980, 1047 UTC.					
13 April 1980 0616 UTC Central California 36.72N, 121.55W Magnitude 4.9	Hollister City Hall 339 Fifth St. (USGS)†	36.85° N 121.40° W	1.4		**	

See footnotes at end of table.

Table 1. - *Summary of accelerograms recovered during January - April 1980* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Direction[3]	Max accl[4] (g)	Duration[5] (s)
18 September 1979- 9 May 1980 Central California Epicenters and magnitudes unknown	Dos Amigos Pumping Plant (CDWR)	36.92° N 120.83° W	-			
	Level 1				**	
	Level 4				**	
	Note: One each additional records recovered at levels 1 and 4; maximum acceleration less than 0.05 g.					

[1] Station owner code:
ACOE - U.S. Army Corps of Engineers.
CDWR - California Department of Water Resources.
MWD - Metropolitan Water District.
SDGE - San Diego Gas and Electric Company.
USGS - U.S. Geological Survey.
VA - Veterans Administration.
† - WWVB time code not legible or instrument not equipped with a radio receiver; correlation of accelerogram with event may be questionable.

[2] S-wave arrival minus trigger time (S - t) interval.

[3] Direction of case acceleration for upward trace deflection on accelerogram. Horizontal components are listed as azimuth in degrees clockwise from north. Vertical components are listed as "up" or "down."

[4] Peak acceleration recorded at ground level on one vertical and two orthogonal horizontal components.
** Denotes maximum acceleration is less than 0.05 g at ground level or less than 0.10 g at non ground-level stations.

[5] Duration between first and last peaks of acceleration greater than 0.10 g.

GPO 587-041/28