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THE SOUTHERN CALIFORNIA NETWORK BULLETIN

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by

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INTRODUCTION

The California Institute of Technology together with the Pasadena Office of the U.S. Geological Survey operates a network of approximately 280 remote seismometers in southern California. Signals from these sites are telemetered to the central processing site at the Caltech Seismological Laboratory in Pasadena. These signals are continuously monitored by computers that detect and record thousands of earthquakes each year. Phase arrival times for these events are picked by human analysts and archived along with digital seismograms. All data aquisition, processing and archiving is achieved using the CUSP system. These data are used to compile the *Southern California Catalog of Earthquakes*; a list beginning in 1932 that currently contains more than 174,000 events. This data set is critical to the evaluation of earthquake hazard in California and to the advancement of geoscience as a whole.

This and previous Network Bulletins are intended to serve several purposes. The most important goal is to make Network data more accessible to current and potential users. It is also important to document the details of Network operation, because only with a full understanding of the process by which the data are produced can researchers use the data responsibly.

NETWORK CONFIGURATION

New Stations. Several new sites have been added since publication of the last Network Bulletin. As in past Bulletins, reports of network changes are not restricted to those that occurred during the reporting period but are as current as possible. An explanation of the conventions used for full station codes can be found in Given *et al.* (1987).

Plans are still underway to telemeter TIN and CWC, two long established sites in Owen's Valley. One or more new sites may also be added in that area.

Site preparation is underway for the new broad-band, high dynamic range site planned for the vicinity of the new Seven Oaks dam being contructed north of Redlands by the U. S. Army Corps of Engineers. Its design will be very similar to the new Streckeisen that has been installed in Pasadena. It will be located in an abandoned water shaft near power plant #2 in the Santa Ana riverbed. The completion date is mid-summer, 1990.

CLI Two horizontal components have been added to an already-existing short-period vertical seismometer site. These two components were added at the site when nearby WLK was removed.

Site name:	Calipatria	
Latitude:	33° 8.45′ N	(33.1408°)
Longitude:	115° 31.64′ W	(115.5273)
Elevation:	-59 m	(-194 ft.)
Date installed:	March 7, 1989	

Full Code	Inst.	Orientation
CLICE	L4	east/west
CLICN	L4	north/south

<u>EDW</u> A new site has been instrumented with a triaxial force-balance accelerometer (FBA) on Edwards Air Force Base. It replaces the short-period vertical seismometer BOO.

Site name:	Edwards Air Force Base	
Latitude:	34° 52.98′ N	(34.8830°)
Longitude:	117° 59.41′ W	(117.9902°)
Elevation:	795 m	(2609 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
EDWCI	FBA	vertical
EDWCJ	FBA	north/south
EDWCK	FBA	east/west

<u>FMA</u> This new site is an University of Southern California (USC) station that was added to the recording system of the CIT/USGS network in order to provide better coverage of the Los Angeles basin.

Site name:	Fort MacArthur	
Latitude:	33° 42.75′ N	(33.7125°)
Longitude:	118° 17.47′ W	(118.2912°)
Elevation:	15 m	(49 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
FMASV	L4	vertical

<u>LCL</u> This new site is an University of Southern California (USC) station that was also added in order to provide better coverage of the Los Angeles basin.

Site name:	Los Cerritos	
Latitude:	33° 50.00′ N	(33.8333°)
Longitude:	118° 12.41′ W	(118.2068°)
Elevation:	-178 m	(-584 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
LCLSV	L4	vertical

LNA This is another University of Southern California (USC) station that was added in order to provide better coverage of the Los Angeles basin.

Site name:	Los Alomitos	
Latitude:	33° 47.35′ N	(33.7892°)
Longitude:	118° 3.27′ W	(118.0545°)
Elevation:	-117 m	(-384 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
LNASV	L4	vertical

LOM This new site is also an University of Southern California (USC) station that was added in order to provide better coverage of the Los Angeles basin.

Site name:	Lomita	
Latitude:	33° 47.71′ N	(33.7952°)
Longitude:	118° 16.76′ W	(118.2793°)
Elevation:	-173 m	(-567 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
LOMSV	L4	vertical

MMI This new site is a Northern California station from Menlo Park added to get more accurate earthquake locations in the Mammoth area.

Site name:	Miami Mountain	
Latitude:	37° 25.20′ N	(37.4200°)
Longitude:	119° 44.56′ W	(119.7427°)
Elevation:	1295 m	(4248 ft.)
Date installed:	May 12, 1989	

Full Code	Inst.	Orientation
MMIMV	L4	vertical

PVPZ This new site is another University of Southern California (USC) station.

Site name:	Palos Verdes	
Latitude:	33° 47.20′ N	(33.7867°)
Longitude:	118° 24.15′ W	(118.4025°)
Elevation:	160 m	(525 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
PVPSZ	L4	vertical

<u>SC1</u> This new site is another University of Southern California (USC) station.

Site name:	University of Southern California	
Latitude:	34° 1.15′ N	(34.0192°)
Longitude:	118° 17.12′ W	(118.2853°)
Elevation:	-4 m	(-13 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
SC1SV	GUR1g	vertical

<u>TAB</u> A new short-period vertical instrument was installed at on Table Mountain. It was installed to replace BLU which was removed due to repeated vandalism and inaccessibility.

Site name:	Table Mountain	
Latitude:	34° 22.91′ N	(34.3818°)
Longitude:	117° 40.84′ W	(117.6807°)
Elevation:	2284 m	(7492 ft.)
Date installed:	November 30, 1989	

Full Code	Inst.	Orientation
TABCV	L4	vertical
TABCZ	L4	vertical low-gain

<u>TPR</u> This is also an University of Southern California (USC) station.

Site name:	Trippet Ranch	
Latitude:	34° 5.33′ N	(34.0888°)
Longitude:	118° 35.20′ W	(118.5867°)
Elevation:	-1 m	(-3 ft.)
Date installed:	January 5, 1990	

Full Code	Inst.	Orientation
TPRSV	SS-1	vertical

<u>WIS</u> An east-west component has been added to the already existing short-period vertical seismometer at this site during a sequence of events in the Brawley area.

Site name:	Wister	
Latitude:	33° 16.56′ N	(33.2760°)
Longitude:	115° 35.58′ W	(115.5930°)
Elevation:	-68 m	(-223 ft.)
Date installed:	March 7, 1989	

Full Code	Inst.	Orientation
WISCE	L4	east-west

XTL A short-period vertical seismometer has been installed at Crystal Lake to replace FAL which was removed because of inaccessibility due to failure of the dirt road used to reach the station.

Site name:	Crystal Lake	
Latitude:	34° 17.74′ N	(34.2957°)
Longitude:	117° 51.68′ W	(117.8613°)
Elevation:	1670 m	(5478 ft.)
Date installed:	February 21, 1989	

Full Code	Inst.	Orientation
XTLCV	L4	vertical

Discontinued Stations. A number of instruments have been removed since the last Bulletin was released. These removals are summerized in Table 1. Repeated vandalism problems led to the removal of BLU, LAN, and SLT. FAL was removed when the dirt road used to access the site was washed out. WHS was removed in order to thin out the dense network in the Coso area and use the instrument elsewhere. WLK was removed due to site service problems with the phone cable. BOO was removed when EDW was installed.

▪ Table 1. Discontinued stations

Code	Date Discontinued
BLU	April 4, 1989
BLUZ	April 4, 1989
FAL	February 21, 1989
LAN	June 9, 1989
MNP	May 12, 1989
SLT	June 12, 1989
WHS	March 7, 1989
WLK	March 8, 1989

Gain Changes of Network Stations. In order to make the best use of the limited dynamic range of the telemetry system, station gains should be set at levels such that the ambient seismic noise does not take up a significant portion of the dynamic range. (There are exceptions to this in the Imperial Valley, where high-frequency earthquakes signals, which are smaller in amplitude than the low-frequency seismic noise, can still be clearly seen.) Noise levels for the seismic stations were checked at four random times during May 1989, and the gains of the 24 most noisy stations were reduced. The same exercise was repeated in October 1989 and the gains of 42 more stations were reduced. Gains were reduced so that the peak to peak amplitudes of the seismic noise level were generally 50 to 100 counts. (The dynamic range of the telemetry system is ±1802 counts).

New Table of Instrument Response. Many changes have been made in the last year which changed the instrument responses of many stations. New VCO settings of 125 Hz at 4.05 volts were completed at most stations, and many attenuation settings have been raised in order to reduce the background noise. Figure 1 provides a summary of the instrument responses of the J120, J101M, and Caltech discriminator types at a variety of attenuation settings. Appendix A lists all the current settings which affect the instrument response.

Analysis of Network Calibration Pulses. A system to produce daily calibration pulses is included in most of the stations of the network. The signal generated in the VCO/Amplifier component consists of a coded station identification, plus/minus voltage steps sent through the seismometer and plus/minus voltage steps sent through the amplifier with the seismometer removed. The voltage input for the calibration signals, which depend on the attenuation settings, are given in Table 2. There is no systematic procedure for saving calibration pulses; however, when a calibration pulse happens to be recorded during a system trigger, it is saved. Calibration pulses from 68 stations recorded during 1988 and 1989 were examined to check for possible instrument problems.

A program was written that matches synthetic calibration pulses with the recorded pulses to check the natural frequency and damping of the seismometer and overall system gain. Synthetic calibration pulses were constructed for a range of natural frequencies from 0.5 to 2.0 Hz in increments of 0.05 Hz and a range of damping from 50% to 100% of critical in 10% increments. A least-squares procedure was used to find the best match of the synthetic calibration pulse to the data. A routine to calculate the cross correlation between the synthetic and data was also used to ensure that the synthetic and data were properly lined up in time.

The tabulated results from this analysis are shown in Figure 2. The natural frequencies obtained tend to be a little higher than the standard 1.0 Hz. It is unclear if this is real or a systematic bias of the analysis. A few seismometers were found to have natural frequencies higher than 1.5 Hz. These seismometers were replaced in the field, then examined in the workshop. It was confirmed that there were various problems with these instruments. The seismometer damping appears to be set fairly closely to the standard value of 70% of critical for most of the sites. The absolute gain for most of the stations is within about 30% of the critical value, however, there is a wide range of scatter with quite a few stations that are off by significantly more.

The procedure used here provides a fairly easy method of checking on the health of network stations. Major problems with the seismometer, the component in our system where problems can most easily occur unnoticed, can usually be identified. To continue to improve our knowledge of the absolute instrument responses for the network, we plan to continue analyzing the calibration pulses as they are recorded, to search for faulty seismometers, and to look into inconsistencies with the theoretical instrument gains.

■ **Table 2. Calibration Voltages Applied to USGS Stations**

Attenuation setting(db)	J402 amplifier gain	Calibration voltage
0	37584	0.0025
6	17378	0.0050
12	8318	0.0100
18	4169	0.0200
24	2089	0.0400
30	1047	0.0800
36	525	0.1610*

*Calibration voltage is also 0.161 v for attenuations higher than 36 db.

FBA Calibration. Five sites in southern California now have three-component force-balance accelerometers (FBA) installed. The gains on all the FBA's have been adjusted at various times in an attempt to set their gains to the values that would recover the most useful data from each site. The calibration for each FBA and the date each became active is listed in Table 3. The last entry for each FBA is the current calibration.

■ **Table 3. FBA Calibrations**

Site Name	Component Codes	Calibration $counts/(cm/sec^2)$	Beginning Date
BRA	I, J, K	1.047	September 15, 1987
		4.188	March 7, 1989
		3.685	April 6, 1989
EDW	I, J, K	3.685	February 5, 1990
GSA	A, B, C	16.752	October 6, 1987
		33.504	December 6, 1988
GSA	I, J, K	2.094	October 6, 1987
		1.047	December 6, 1988
GRV	I, J, K	0.993	October 8, 1987
		1.238	February 22, 1988
		1.092	April 3, 1989
		3.685	April 7, 1989
SBP	I, J, K	1.047	October 18, 1987
		4.188	March 9, 1989
		3.685	April 4, 1989

Please note the values for GSA and GVR were reported incorrectly in the previous Network Bulletin July - December, 1987 (Given *et al.*, 1989).

PAS IRIS-TERRAscope Station Calibration. On November 21, 1988 the feedback boxes for the north-south (NS) and vertical Very-Broad-Band (VBB) seismometers, PAS IRIS instrument at Kresge Lab. in Pasadena, were switched in order to determine if the source of a recording problem was being caused by the feedback box. As a result, the responses of these two components changed. After comparing simulated Wood-Anderson records obtained from the VBB (Streckeisen) and FBA (Kinemetrics) systems, Hiroo Kanamori and Jim Mori determined that the gain of VBB is 25% lower for the NS component and 20% larger for the vertical component than indicated in the station log. This is probably due to the different capacitor values for each component. The NS feedback originally had a capacitance value of 6.30μF. and the vertical feedback had a capacitance value of 7.77μF. When the two feedback boxes were switched, their different capacitance values caused the effective gain of the NS component to decrease and the vertical component to increase. The feedback boxes will be switched back in the future, but in the meantime those people using the data should be aware of this discrepancy.

VCO Codes and Settings. Most of the VCO's have recently been replaced or modified. Each VCO type, the code used to reference it in bookkeeping records and in the network configuration database, and the frequency and voltage settings are listed in Table 4.

■ Table 4. VCO Codes and Settings

VCO Code	VCO Type	Frequency Voltage Settings
J1	J302	100 Hz at 2.7 volts
J2	J302M	modified calibrator, 100 Hz at 2.7 volts
J3	J302M	modified calibrator w/ frequency stabilizer 100 Hz at 2.7 volts
J4	J402	100 Hz at 2.7 volts
J5	J502	115 Hz at 4.05 volts
J5M	J502M	separate J601 P/S board, 115 Hz at 4.05 volts
J312D	J312D	modified for +-5 volts operation, clamping diodes, 105 Hz at 4.05 volts
J412H	J412H	12 volt input to +-5 volt operation, 105 Hz at 4.05 volts
J512M	J512M	modified power supply board, 105 Hz at 4.05 volts
J512A	J512A	improved power supply on board, 105 Hz at 4.05 volts
J512B	J512B	2 frequencies, 2 gains for hi/low gain sites

NOTES:

* Suffix X means modified low gain (24db higher attenuation)
* All VCO's on 400 Hz phone lines are 60 Hz deviation
* A "1" as a middle digit in the VCO name indicates a setting of 105 Hz at 4.05 volts
* Accurate VCO gain information necessary to calculate instrument response is unavailable at this time

Calculating Instrument Response. Since the last description of the instrument response in the Network Bulletin (January–June, 1986), there have been many adjustments in the VCO settings and discriminator settings, among other changes. The equation to determine the gain remains the same, but some of the past constants are now variables depending on the instrument in question. The absolute gain of any instrument, after Stewart and O'Neill (1980), is:

$$GAIN = GLE \times GSA \times DVCO \times DDSC \times L$$

where

GAIN is the system gain in units of counts/cm/sec (counts/cm/sec^2 for FBA's)
GLE is the seismometer constant (volts/cm/sec) (volts/cm/sec2 for FBA's)
GSA is the gain of the amplifier (dimensionless)
DVCO is the Voltage Controlled Oscillator ratio of hertz to volts (Hz/volts)
DDSC is the discriminator ratio of volts to hertz (volts/Hz)
L is the digitizer ratio of counts per volt (counts/volts)

Some stations vary, but the most common values are shown in Table 5.

▪ Table 5. Common Instrument Parameters

	velocity transducers	FBA's
GLE	1.0 volt/cm/sec	10 volts / 2 g
GSA	$10^{(90.4-gain)/20}$	1.0
DVCO	105 Hz / 4.05 volts	125 Hz / 2.5 volts
DDSC	2.2 volts / 125 Hz	2.2 volts / 125 Hz
L	2048 counts / 2.5 volts	2048 counts / 2.5 volts

The Network Configuration Database. The network history database was developed in order to provide researchers with accurate instrument response for all the network stations at any point in time. The structure of the database (using dBase III) has been modified since the last publication of the Southern California Network Bulletin (Given *et al.*, 1989) in order to make the "bookkeeping" more efficient.

The entire database now consists of six separate databases grouped by information type: MAIN.DBF, SEIS.DBF, VCO_DISC.DBF, COMM.DBF, POW.DBF, and POL.DBF. Characteristics of each database are described in Appendix B. Each item is listed by the field name, data type, and field length as they occur in the database.

NETWORK OPERATIONS

Status of Processing. The status of each month of catalog data since the advent of digital recording is described in Table 6. Events for months marked preliminary (**P**) have been timed but have not yet run the gauntlet of quality checking, addition of helicorder amplitudes and rearchiving necessary to become final (**F**). For months marked "pinked" (**Pnk**), larger events (≈ 3.0) have only been timed crudely on a few stations and smaller events are absent. A period in 1980–1981 has actually been timed and digital seismograms are available, but the "pinked" version is still used for any purpose requiring good magnitudes or completeness for large earthquakes: some events and magnitudes are missing otherwise. An increased effort has been made in the last six months to finalize the most recent 8 years of data. As a result, almost all months in 1983 – 1988 have been finalized. The effort will now be shifted to reloading and finalizing older data.

▪ Table 6. Processing Status of Network Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	P	P	P	P	P	P	P	P	P	P	P	P
1978	F	F	F	F	F	F	F	F	F	F	F	F
1979	P	P	P	P	P	P	P	P	P	P	P	P
1980	P	P	P	P	Pnk	Pnk	Pnk	Pnk	Pnk	Pnk	Pnk	Pnk
1981	Pnk	Pnk	P	P	P	P	P	P	P	P	P	P
1982	P	P	P	P	P	P	P	P	P	P	P	P
1983	P	P	P	Pnk	Pnk	Pnk	Pnk	P	P	F	F	F
1984	F	F	F	F	F	F	F	F	F	F	F	F
1985	F	F	F	F	F	F	F	F	F	F	F	F
1986	F	F	F	F	F	F	P	F	F	F	F	F
1987	F	F	F	F	F	F	F	F	F	F	F	F
1988	F	F	F	F	F	F	F	F	F	F	F	F
1989	F	F	F	P	P	P	P	P	P	P	P	P
1990	P	P	P	P								

F = final, Pnk = "pinked", P = preliminary

Calculation of Synthetic Wood-Anderson Records. Since August 1989 a program has been running on the on-line computer to automatically calculate synthetic Wood-Anderson records from 23 low-gain seismometer components (at 16 sites) and 18 Force Balance Accelerometer (FBA) components (at 5 sites), for larger events. Figure 3 shows the locations of these low-gain and FBA sites. The synthesized Wood-Anderson records along with the maximum accelerations recorded on the FBA's are produced about 10 to 15 minutes following the event. To the present, we have recorded about 25 events greater than magnitude 3.5.

For the magnitude determination, station corrections are included for most of the low-gain components. The station corrections were calculated using a set of 27 earthquakes ranging in magnitude from 3.5 to 5.4 recorded from January 1988 through June

1989. The low-gain data from these events were converted into synthetic Wood-Anderson records using the same method as is used by the currently running on-line program. Local magnitudes were calculated from the processed low-gain data and station corrections estimated so that the magnitudes matched the network magnitudes determined from actual Wood-Anderson instruments. Station corrections are listed in Table 7.

The present system allows rapid access to amplitude information from 16 low-gain and 5 FBA sites following a significant earthquake. The local magnitudes presently calculated from the low-gain data are internally quite consistent, with a range of ±0.2 to ±0.3 magnitude units. During this time period we have recorded a few events with observable accelerations on FBA components. The M_L4.2 earthquake of December 12, 1989 near Cajon Pass produced 0.02g at Strawberry Peak (SBP), 15 km from the epicenter. The February 28, 1990 Upland earthquake (M_L5.5) and several magnitude 4 aftershocks produced accelerations of a few hundredths of a g at 40km distance.

Table 7. Station Corrections (as of 5/1/90) Used to Calculate Local Magnitudes from Low-gain Stations

Station	Correction	Station	Correction	Station	Correction
BRAZ	+0.39	GSAZ	+0.04	PEMZ	+0.01
COYZ	+0.23	GSAN	-0.25	PMCZ	-0.20
CPMZ	+0.06	GSAE	-0.25	POBZ	+0.17
CTWZ	-0.03	GVRN	-0.40	RAYZ	+0.18
EWCZ	+0.20	GVRE	-0.40	SBPZ	+0.80
EWCN	+0.10	LJBZ	+0.28	SILZ	+0.13
EWCE	+0.10	LJBN	+0.08	TABZ	+0.00
GAVZ	+0.21	LJBE	+0.08	EDWZ	+0.20
CLIE	-0.60	CLIN	-0.60		

RESEARCH NOTES

Programs for Processing Streckeisen Data. Several programs have been written for processing and plotting Streckeisen data on a VAX 750. The first two, STRECK and STRECKWA, were written by Lisa Wald, modified from subroutines from Hiroo Kanamori. STRECKWA is used specifically to convert a Streckeisen record into a Wood-Anderson record. The Streckeisen instrument response is removed in the frequency domain and then the Wood-Anderson response is convolved with the resulting ground displacement record. STRECK is used to convert the Streckeisen record into a variety of different types of records of choice including:

ground displacement
WWSSN 15-100
WWSSN 30-90
WWSSN 100-300
WWSSN SP

Benioff 1-90
Torsion (6.0s, 0.8s)

The deconvolution and convolution takes place in frequency domain.

STRECKPLOT will plot one to three components for an individual earthquake from the raw Streckeisen data file or any of the various output files created by the STRECKWA or STRECK. These programs are in the LEAP collection (Wald and Jones,1989) and are found in [LEAP.STRECK] on the GSVAX1 (USER$DISK) and on the CITVAX (DISK0) in Pasadena. Documentation and example runs are also on both VAX's in [LEAP.DOC].

SYNOPSIS OF SEISMICITY

A total of 11,898 earthquakes and 1,293 blasts were cataloged for 1988 (Figure 4). The annual total of earthquakes is lower than for any of the previous five years because there were no large or prolific sequences and because the level of completeness (detection of *all* events) has been increased from about M_{CA} 1.5 to M_{CA} 1.8. (We do not have M_L's below about 2.2.) Our detection threshold, the smallest recorded earthquake, is actually much lower. Of the cataloged events, 204 were greater than or equal to M_L 3.0 (Appendix C, D). The largest earthquake in 1988 had an M_L of 5.4 and was located about 20 km northeast of the junction of the Garlock and San Andreas faults. Focal mechanisms for 39 events ($M_L \geq 3.5$) are shown in Figure 6.

For the following discussion southern California has been divided into eleven sub-regions (Figure 7). These regions are arbitrary, but useful for discussing characteristics of seismicity in a manageable context. Figures 8a and 8b and 9a and 9b summarize the activity of each sub-region over the past four years. Figures 8a and 8b cover through June 1988, and Figures 9a and 9b cover through December 1988. A separate discussion section follows for those regions with notable activity.

Imperial Valley – Region 1.

Several earthquake swarms occurred in the vicinity of Obsidian Butte at the south edge of the Salton Sea in 1988. Such swarms are common in the Brawley Seismic Zone, the broad band of seismicity that connects the north end of the Imperial fault to the south end of the San Andreas fault. However, since 1986, the number of swarms in the Obsidian Butte area has increased while the number of swarms in the rest of the Brawley Seismic Zone has decreased.

A sequence of earthquake activity that might best be characterized as a swarm of swarms began gradually in March and grew in intensity through June. At least five temporally distinct subswarms occurred during this period with the most intense producing about 12 events per day. None of the earthquakes exceeded M_L 3.0. The events were scattered on a roughly north-south trend around Obsidian Butte (Figure 10) and showed a weak migration of activity from north to south. The activity was restricted to depths of less than 8 km.

Another series of swarms occurred later in the year near Red Hill, just southwest of the Salton Sea (Figure 10). The first, on October 19 - 20, produced three events larger than M_L 3.0 (3.7, 3.4, 3.1). The second burst of activity occurred on October 23 and produced no earthquakes larger than M_L 3.0. A third swarm of events smaller than M_L 3.0 followed on December 2. Some scattered earthquakes with M_L up to 3.1 followed in late December. None of these swarms were spatially distinct. Each lasted about six hours and have focal mechanisms that indicate thrust motion on planes striking west to northwest (not shown).

All of the swarms were extremely shallow, with nearly all events locating at less than 2 km depth. A geothermal power plant is located at Red Hill and it is possible that the shallow earthquakes are related to reservoir pressure changes caused by the withdrawal of pore fluids.

South San Jacinto – Region 2.

Aftershocks of the November 24, 1987 Superstition Hills earthquake sequence continued with a normal rate of decay into 1988. However, a large, late aftershock (M_L 4.6) occurred on January 28 at the southeast edge of the aftershock distribution.

On May 17 an M_L 4.2 earthquake occurred within the San Jacinto fault zone. Its focal mechanism is consistant with right lateral strike slip on the northwest striking Coyote Creek branch (Figure 6, number 19). The aftershocks are very tightly clustered and locate within 1 km horizontally and 1.5 km vertically of the mainshock. This is about the size of location errors in the area. The earthquakes were at a depth of about 8 km. This event is located in the aftershock area of the M_L 6.4 Borrego Mountain earthquke of 1968 and about midway between that event and the M_L 5.9 Coyote Mountain earthquake of 1969.

The San Jacinto fault zone produced another significant earthquake on July 2. This M_L 4.3 event was centered within the San Jacinto fault zone where it splays into three subparallel strands. The mainshock focal mechanism indicates that slip occurred on a normal cross fault that accomodates differential slip between the principal right-lateral strike-slip strands. This was the largest of several clusters of activity to occur in 1988 in the area of high seismicity that marks the southeastern boundary of the "Anza gap". The July 2 event was within 2 km of the 1937 M_L 6.0 epicenter as relocated by Sanders *et al.* (1986).

South Elsinore – Region 3.

As noted by Given *et al.* (1989), the Superstition Hills earthquake sequence of November 24, 1987 (M_S 6.2, 6.6) was accompanied by a dramatic increase in activity in an area about 25 km to the southwest, near the U.S. - Mexican border. The increase began about eight hours after the second mainshock and continued through 1988 (Figures 8a and 9a). The location and timing of these events strongly suggest that they were induced by the stress changes caused by the Superstition Hills sequence.

Activity was distributed over a broad area and did not delineate mapped surface faults (Figure 10). Events did, however, occur in spatial and temporal clusters, some of which defined northeast striking lineations. One cluster of events was clearly associated with a bifurcation near the north end of the Laguna Salada fault which strikes for about 70 km south-eastward into Baja California (Kahle *et al.* 1984).

A majority of the events occurred between the Laguna Salada fault and the northern end of the Sierra Juàrez fault, which is mapped as a broad zone of splays by Kahle *et al.* (1984).

San Diego – Region 4.

The area of the Oceanside earthquake of July 13, 1986 (M_L 5.4) continued to be extremely prolific. The frequency of activity is decaying, but at an unusually slow rate. That area produced 18 event greater than or equal to M_L 3.0 in 1988. Focal mechanisms for events in the sequence show thrusting on north to northeast striking planes (Figure 6, numbers 2,18).

An M_L 3.8 earthquake happened on August 20 about 60 km off shore from San Diego. Its location and focal mechanism, though poorly constrained, are consistant with right-lateral strike slip on the northeast striking San Clemente fault. This fault produced an M_L 5.9 event near the same area on December 26, 1951.

Los Angeles Coast – Region 5.

The area immediately off the coast of Los Angeles showed an unusual amount of activity in the latter part of 1988. On September 12 an M_L 3.9 occurred just west of Manhattan Beach and was widely felt in west Los Angeles. This earthquake had an east-west striking thrust mechanism (Figure 6, number 33) but in map view locates near the northern end of the northwest striking Palos Verdes fault. An M_L 3.4 oblique-slip event occurred in the same place on June 26, 1986.

The southern end of the Palos Verdes fault was the site of an M_L 4.5 earthquake on November 20. The focal mechanism of this event shows reverse slip on a northwest striking plane (Figure 6, number 37). It was preceded by two foreshocks; an M_L 2.9 13 minutes before and an M_L 3.0 ten minutes before. an M_L 3.0 event had occurred in the same place on September 2.

During 1987 and 1988, the Los Angeles metropolitan region experienced numerous felt earthquakes. This apparent increase prompted an analysis of the Caltech/USGS earthquake catalog for the Los Angeles Basin and for the time period from 1975 to June 30, 1989. The rate of background seismicity in Los Angeles, within a circle, 40 km in radius, centered on 34° 0′N, 118° 20′W, in the Baldwin Hills, has been evaluated using the methodology of Matthews and Reasenberg (1988). From 1975 to June 1989, the average rate of magnitude 2.3 or greater earthquake sequences was 22 per year, with variations from 14 events per year to 60 events per year. The only statistically significant variation in rate occurs for an interval ending at the end of the sample (July 1, 1989) and starting 3.3 years earlier in March 1986. The rate since March 1986 has been 1.75 times greater than the rate from 1975 to March 1986 (Figure 11). A similar increase has not been seen in the rest of southern California. The increased activity includes the 1987 Whittier Narrows earthquake (M_L 5.9).

Coincident with the change in rate of earthquake activity has been a change in both the depth of the earthquakes and the b-value (the exponent in the magnitude-frequency relationship, $N = 10^{-bM}$). The median depth of faulting within this region of increased seismicity has decreased from 7 km to 9.5 km and the third quartile has dropped from 9 km to 13 km. The depths of these earthquakes have been recalculated using all available phase data and regionally appropriate velocity models. Although the median depth of faulting has become deeper, the maximum depth of faulting has not increased significantly. Rather, the maximum depth of faulting has stayed at about 16–17 km but the number of earthquakes occurring between 10 km and 17 km and the magnitudes of those earthquakes has gone up dramatically. In addition, the shallowest parts of the basin (above 4 km) has become quiet with all but 4 of the earthquakes since 1986 occurring below 4.0 km.

The greatest concentration of excess earthquakes in the last three years is in the Pasadena–Whittier area (Figure 12). The rate of activity in this region went from 2 to 8 $M_L \geq 2.3$ events per year, excluding aftershocks but including the Whittier Narrows M_L 5.9, the 1988 Pasadena M_L 4.9 and 1989 Montebello M_L 4.5, 4.3 earthquakes. North of the Los Angeles basin, several smaller earthquakes (largest is M_L 3.3) were recorded near the aftershock zone of the 1971 San Feranndo earthquake leading to increased seismicity in that region. The west side of Los Angeles including the area along the Torrance-Wilmington anticline, offshore in the Santa Monica Bay and along the Palos Verdes Peninsula, has also been particularly active. The largest of these earthquakes was the M_L 5.0 1989 Malibu earthquake, but most of the events in this cluster have been small.

North Elsinore – Region 6.

Aftershocks of the M_L 5.9 Whittier Narrows earthquake for October 1, 1987 continued with a normal decay rate into 1988. A large, late aftershock of M_L 4.7 occurred on February 11 on the northeast edge of the aftershock distribution. It was the second largest aftershock of the series, second only to the M_L 5.3 aftershock of October 4, 1987 which occurred on a northwest striking right-lateral fault that appeared to define the western boundary of the aftershock zone. The M_L 4.7 late aftershock also occurred on a northwest striking right-lateral fault that may delimit the eastern boundary of the zone.

An M_L 4.9 earthquake occurred on December 3 under Pasadena within about 1 km of the Seismological Lab. It was widely felt and caused some minor damage. The mainshock was quite deep (16 km) and there were unusually few aftershocks.

The sequence is discussed in detail by Jones *et al.* (1990). They argue that the focal mechanism , which shows left-lateral strike-slip on a steeply dipping west-southwest striking plane (Figure 6, number 38), and the aftershock distribution favor movement on the Raymond fault. This fault has long been presumed to be primarily a reverse fault rather than strike-slip.

Kanamori *et al.* (1990) analysed the broadband data from the PAS station which was located about 4 km from the epicenter. They concluded that the event resulted from the rupture of two asperities 0.4 seconds apart and that the stress drop was high; possibly higher than 2 kbar.

San Bernardino – Region 7.

On June 26 an M_L 4.7 happened near Upland. The hypocenter was at a depth of about 9 km and the aftershock sequence was very energetic. The earthquake was at the southern edge of the frontal fault system of the San Gabriel Mountains, however, its orientation is not consistent with thrusting along a frontal fault. Instead, the mechanism and waveform data (Mori and Hartzell, 1990) indicate left lateral strike-slip on a plane striking N41°E and dipping 40° toward the north (Figure 6, numbers 26,29). The location and orientation of this event is consistent with movement on one of a set of northeast striking faults that cut across the frontal thrust system.

This earthquake was a preshock to the larger, M_L 5.5, Upland earthquake of February 28, 1990. This later event had the same sense of displacement and Hiroo Kanamori (unpublished data) has pointed out that the long-period wave forms of the M_L 4.7 and M_L 5.5 events are also very similar.

On December 16 an M_L 4.8 earthquake occurred on the southeast edge of the aftershock zone of the North Palm Springs earthquake of July 1986. The mechanism is the same as those for events within the aftershock zone; oblique right-lateral thrusting on a nearly east-west striking plane (Figure 6, numbers 17,39).

South Sierra Nevada – Region 9.

On July 5 an M_L 4.6 earthquake occurred just south of Lone Pine and west of Owen's Lake. The alignment of aftershocks and the focal mechanism indicate normal slip on a north-south striking fault (Figure 6, numbers 38,20). This is consistant with the event's location between the Sierra Neveda fault and the Owens Valley fault. Both are members of the frontal fault system between the Sierra Nevada mountains and the Owens Valley graben. The Owens Valley fault produced the great M_L 8.0+ earthquake of 1872.

The aftershocks of the M_L 4.6 event died off in the following month only to be abruptly renewed on August 10. This swarmlike burst lasted only about a day before the rate of activity settled down to its previous level.

Kern County – Region 10.

The largest southern California earthquake of the year was the M_L 5.4 Tejon Ranch event of June 10. It was located 5 km north of the Garlock fault and about 20 km from the intersection of the Garlock and San Andreas faults. The focal mechanism shows oblique left-lateral and reverse slip on a plane striking N82°E and dipping 70° to the north (Figure 6, numbers 23,24,35). Aftershocks formed a circular zone with a diameter of about 2 km centered at a depth of 8 km. Lee Silver (personal communication) has suggested that one of the reverse faults in the Tehachapi Mountains rather than the Garlock fault was most likely the causative fault.

Santa Barbara – Region 11.

An M_L 4.0 quake shocked the Santa Barbara Channel on March 23. It was widely felt in Santa Barbara and Ventura counties (Figure 6, number 12). The event occurred at a depth of 21 km on a north-south striking normal fault. The usual mode of stress release for the area is thrusting on shallow faults.

REFERENCES

Given, D. D., Norris, R., Jones, L .M., Hutton, L. K., Johnson, C. E., and S. Hartzell, 1986, The Southern California Network Bulletin, January - June, 1986: *U. S. Geological Survey Open-File Report 86–598*, 28 pp.

Given, D. D., Hutton, L. K., and L. M. Jones, 1987, The Southern California Network Bulletin, July - December, 1986: *U. S. Geological Survey Open-File Report 87–488*, 40 pp.

Given, D. D., Wald, L. A., Jones, L. M., and L. K. Hutton, 1989, The Southern California Network Bulletin, July - December, 1987: *U. S. Geological Survey Open-File Report 89-323*, 16 pp.

Jones, L. M. and P. Reasenberg, 1989, A preliminary assessment of the recent increase in earthquake activity in the Los Angeles region, *U. S. Geological Survey Open-File Report 89-162*, 4 pp.

Jones, L. M., K. E. Sieh, E. Hauksson, and L. K. Hutton, 1990, The 3 December 1988 Pasadena, California earthquake: Evidence for strike-slip motion on the Raymond Fault; *Bull. Seis. Soc. Am.*, v. 80, p. 474.

Kahle, J. E., P. A. Bodin, and G. J Morgan, 1984, Preliminary geologic map oth the California-Baja Calfornia border region; *CDMG Open-file report, 84-59 LA*

Kanamori, H. , J. Mori and T. H. Heaton, 1990, The 3 December 1988, Pasadena earthquake ($M_L = 4.9$) recorded with the very broadband system in Pasadena; *Bull. Seis. Soc. Am.*, v. 80, p. 483.

Mori, J. J. and S. H. Hartzell, 1990, Source inversion of the 1988 Upland, California, earthquake: Determination of a fault plane for a small event; *Bull. Seis. Soc. Am.*, v.80, in press.

Stewart, S. W and M. E. O'Neill, 1980, Calculation of the frequency response of the USGS telemetered short-period seismic system, *U. S. Geological Survey Open-File Report 80-143*, 83 pp.

Wald, L. A. and L. M. Jones, 1989, LEAPing Into CUSP: Local Earthquake Analysis Programs for CUSP Data, *U. S. Geological Survey Open-File Report 89-479*, 90pp.

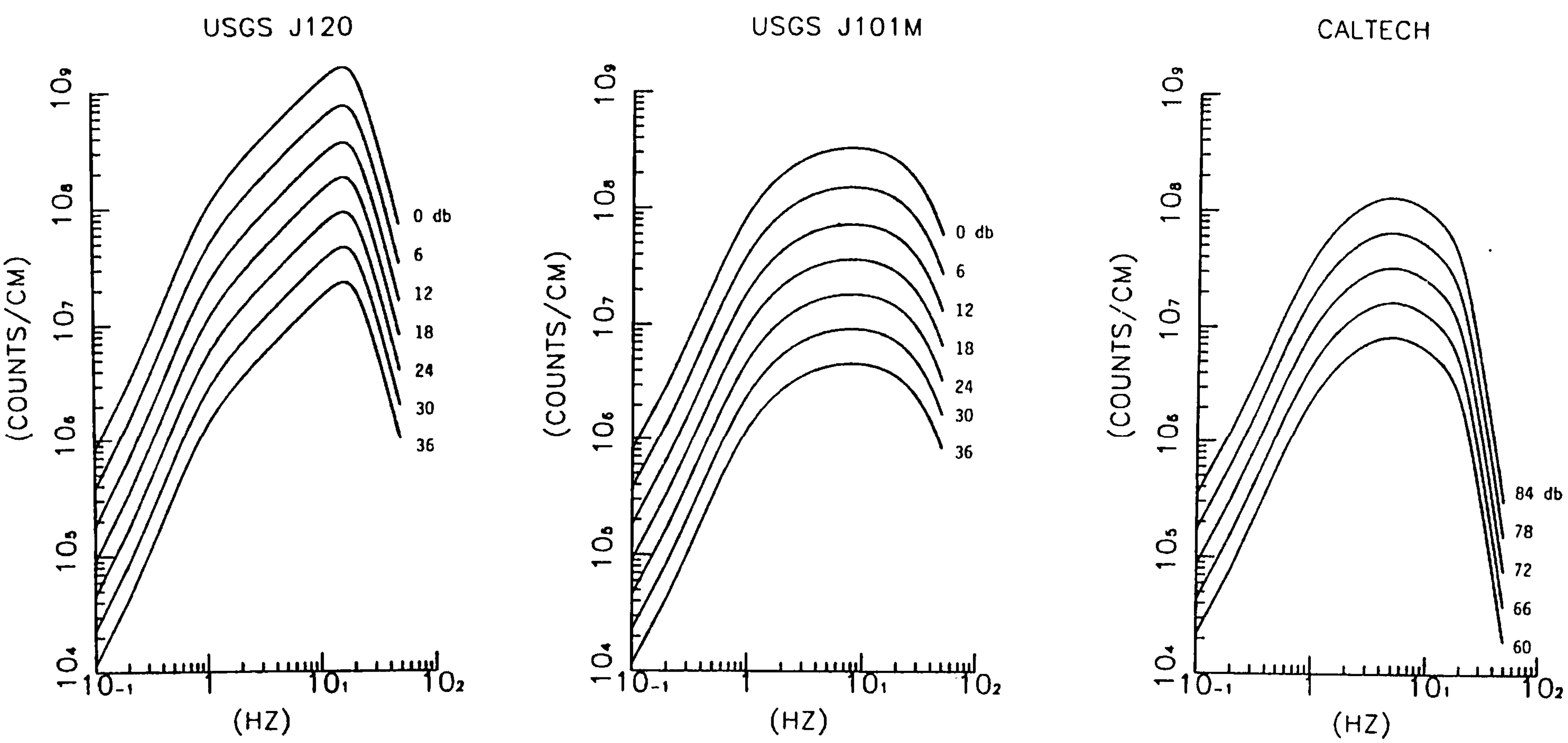

Figure 1. Instrument responses for discriminator types USGS J120, USGS J101M, and Caltech with a variety of attenuation settings.

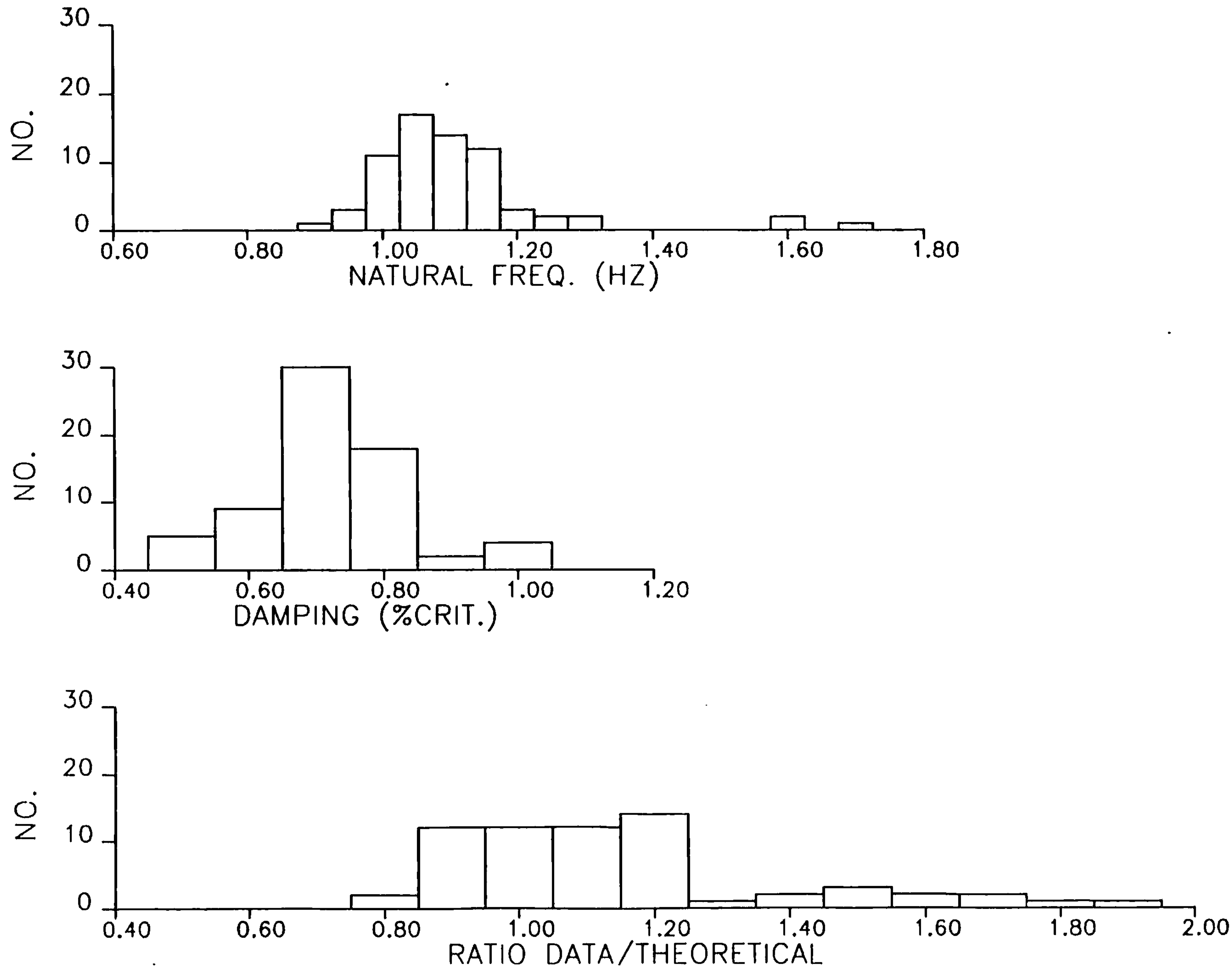

Figure 2. Results of analyzing network calibration pulses. Seismometer natural frequencies (top), seismometer damping (middle), ratio of observed to theoretical system (bottom).

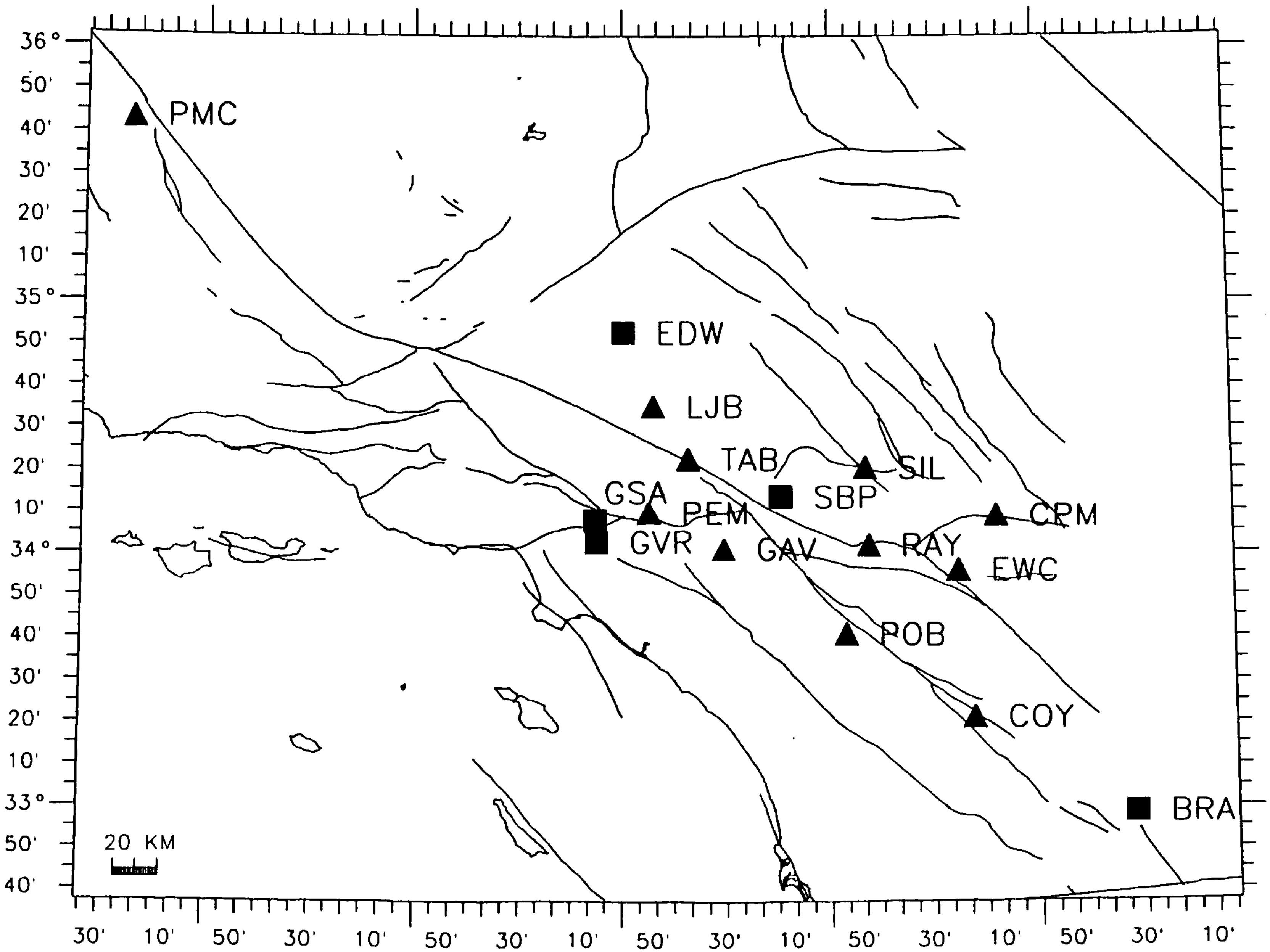

Figure 3. Map showing location of low-gain (triangles) and FBA (squares) sites in the Southern California Seismic Network. All FBA sites also have a low-gain vertical component. GSA has high and low-gain FBA components.

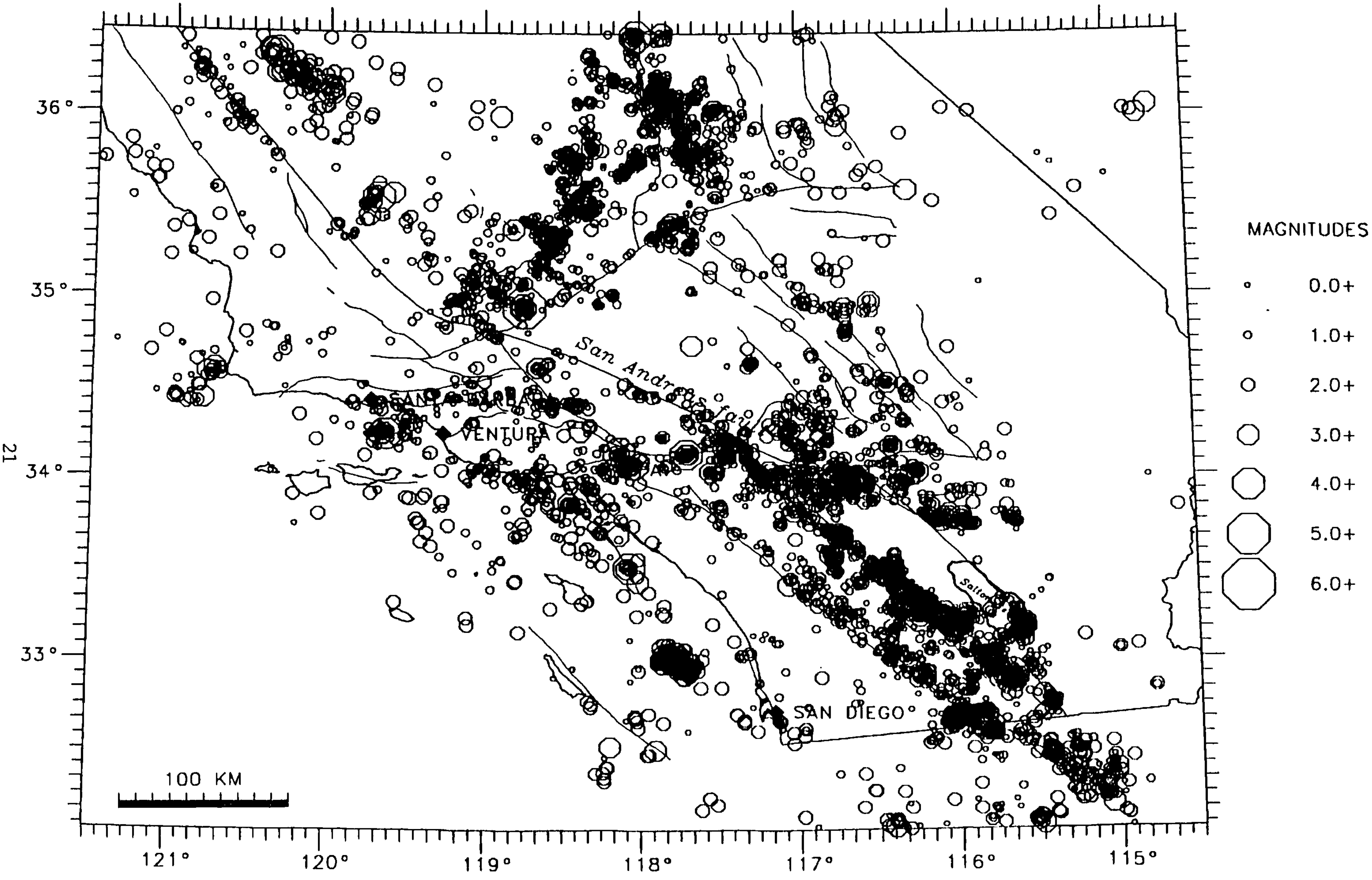

Figure 4. Map of all located earthquakes in southern California for the period of January through December 1988.

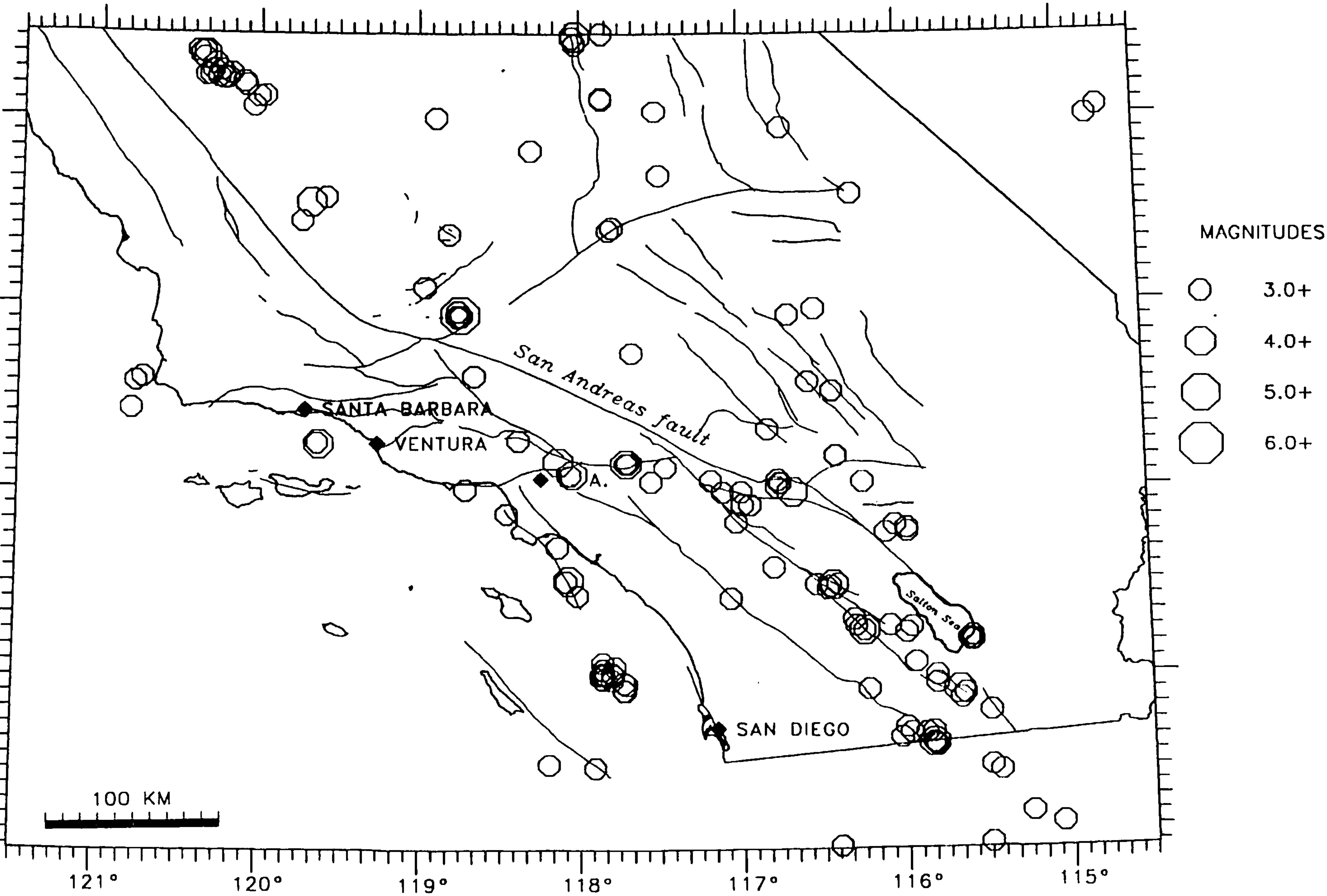

Figure 5. Map of located earthquakes of magnitude 3.0 and larger in southern California for the period of January through December 1988.

Southern California M>3.5 1988

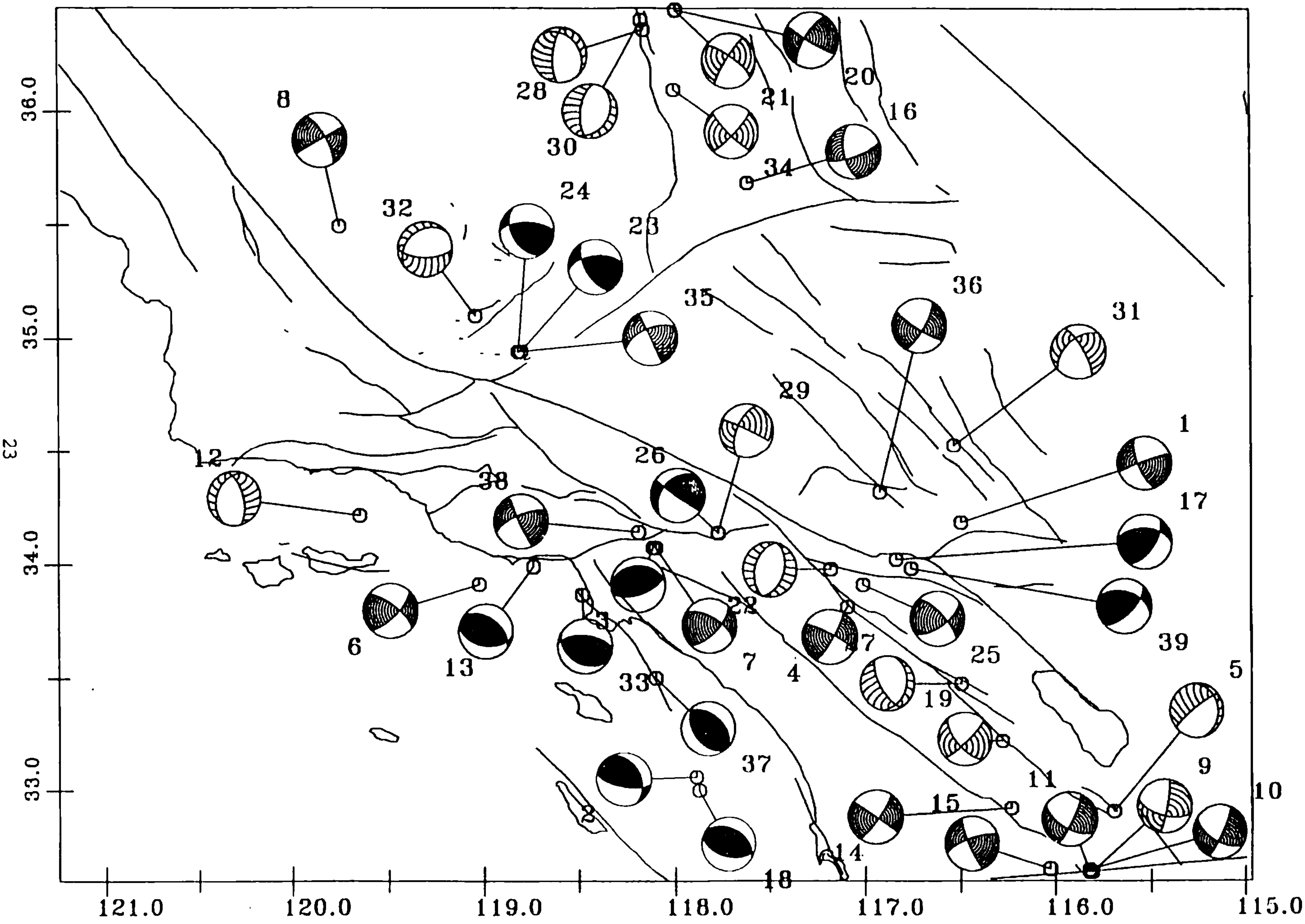

Figure 6. Lower hemisphere focal mechanisms for selected events for the period January through December 1988. Event numbers corrispond to numbers in FM column of Appendices C and D.

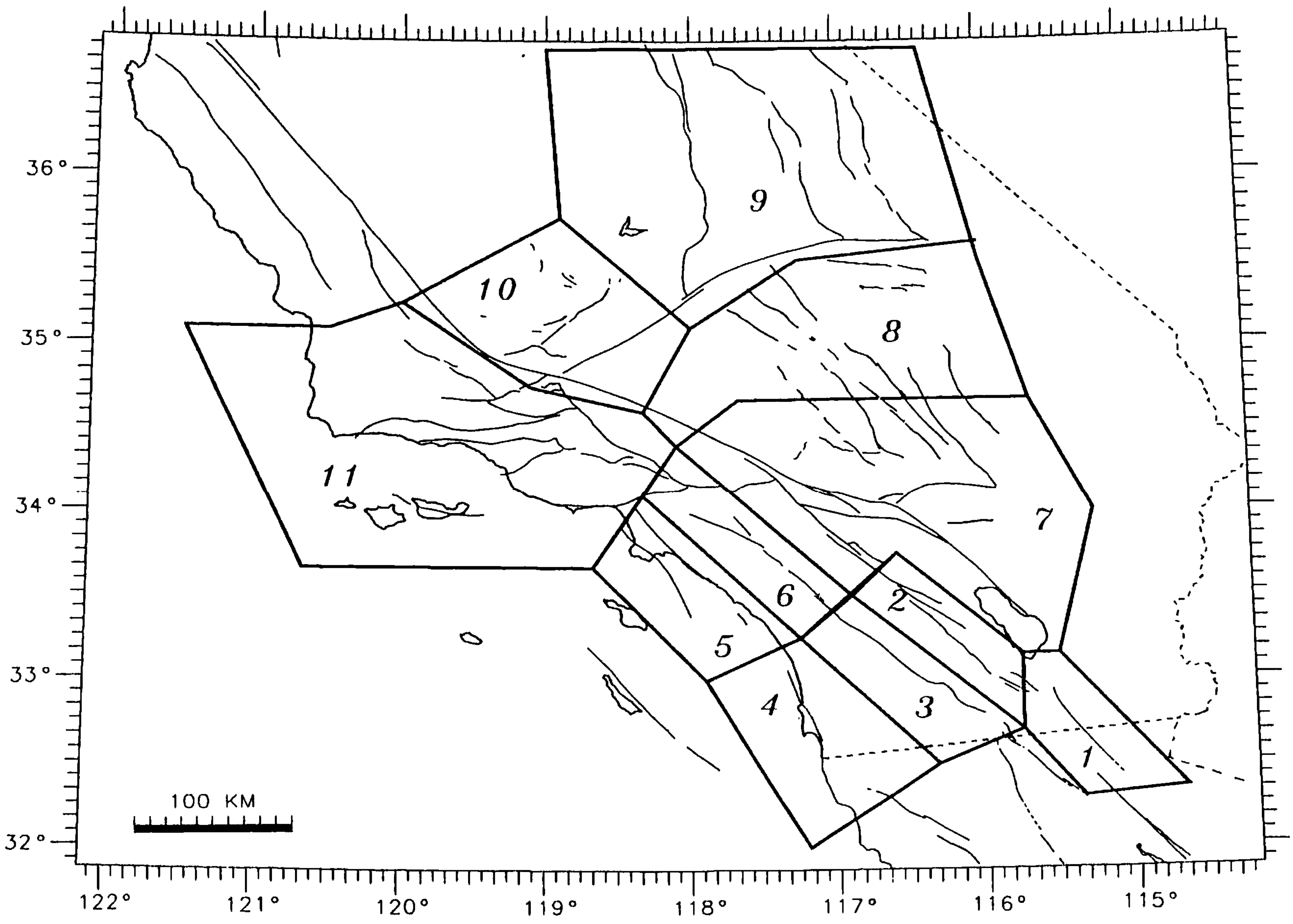

Figure 7. Map of sub-regions used in Figures 8a, 8b, 9a, and 9b. The geographic name of each sub-region, as used in the text, can be found in the headings of Figures 8a, 8b, 9a, and 9b.

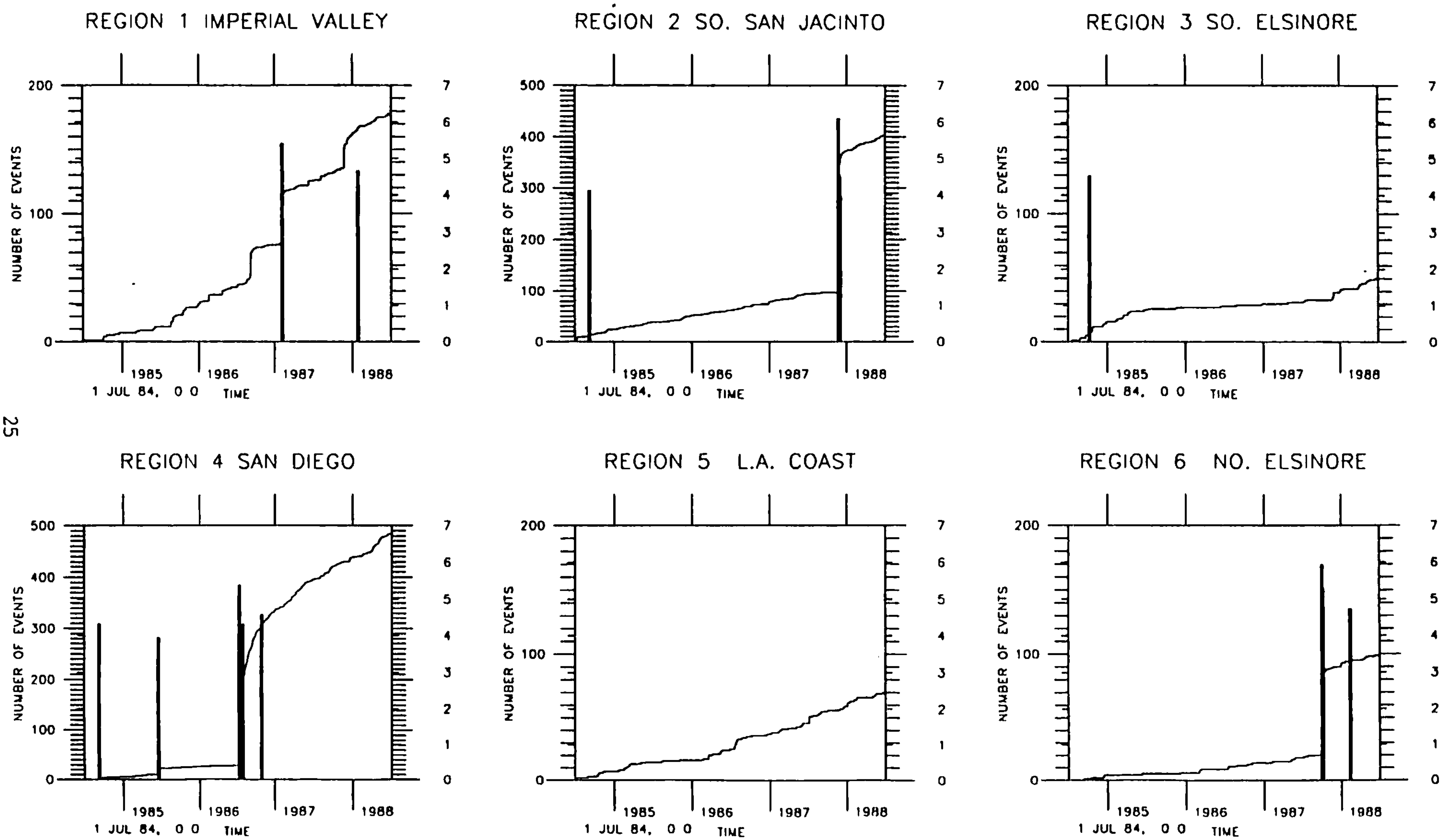

Figure 8a. Cumulative number of events ($M_L \geq 2.5$) in sub-regions 1 through 6 over the four year period ending June 1988. The boundaries of the sub-regions are shown in Figure 7. Vertical bars represent time and magnitude (scale on right) of large events ($M_L \geq 4.0$). Note that the vertical scales of the plots may not be the same.

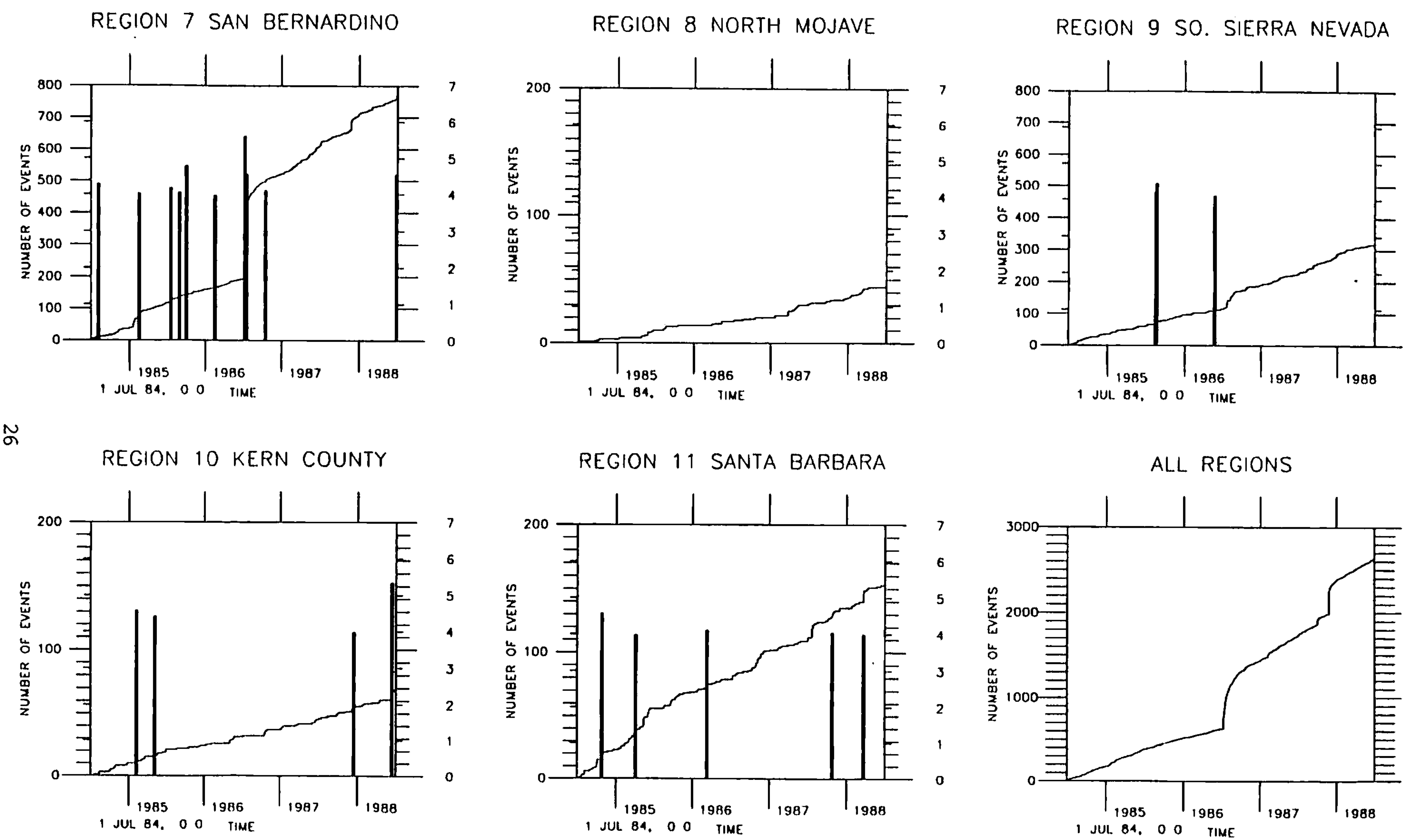

Figure 8b. Cumulative number of events ($M_L \geq 2.5$) in sub-regions 7 through 11 and for all sub-regions over the four year period ending June 1988. The boundaries of the sub-regions are shown in Figure 7. Vertical bars represent time and magnitude (scale on right) of large events ($M_L \geq 4.0$). Note that the vertical scales of the plots may not be the same.

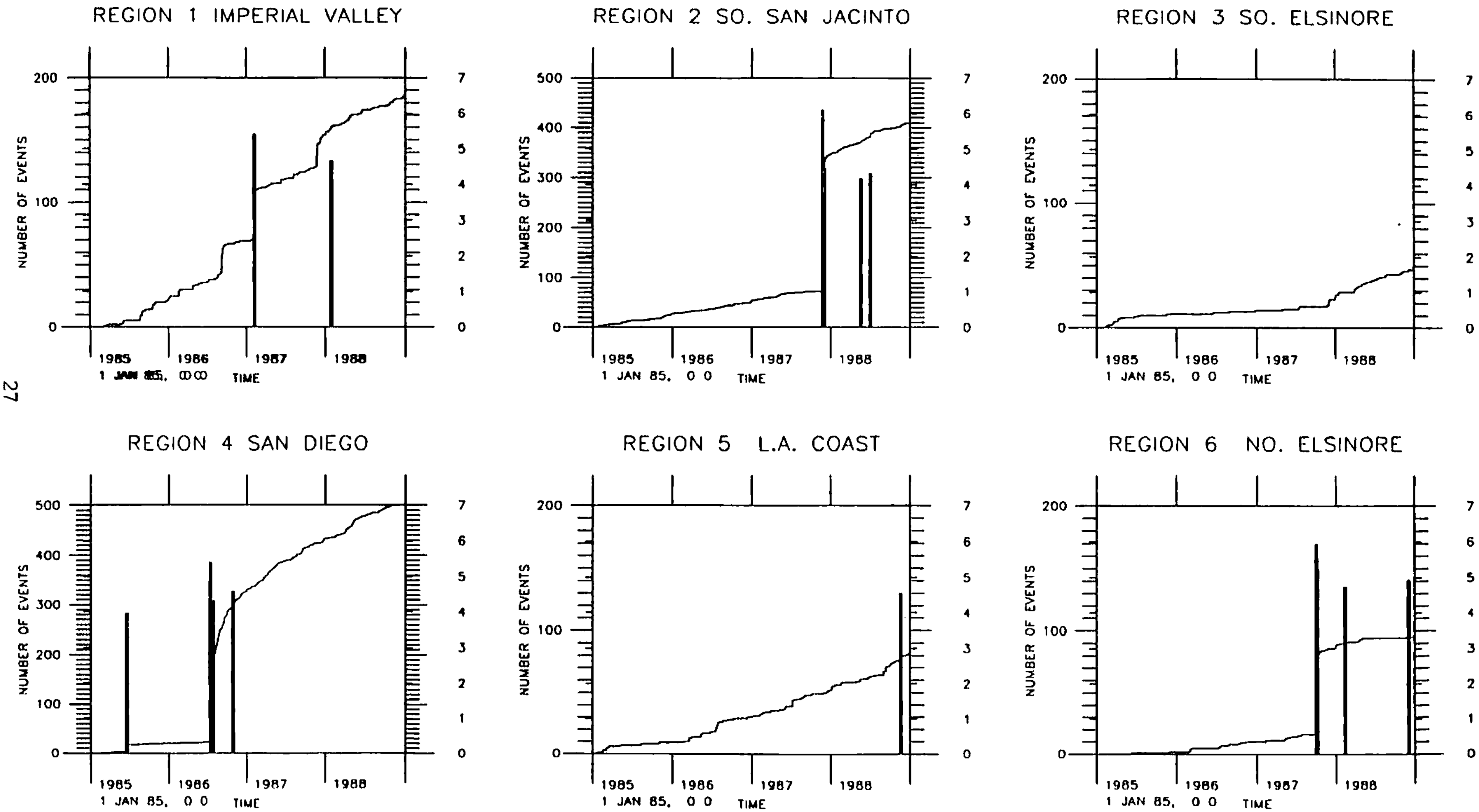

Figure 9a. Cumulative number of events ($M_L \geq 2.5$) in sub-regions 1 through 6 over the four year period ending December 1988. The boundaries of the sub-regions are shown in Figure 7. Vertical bars represent time and magnitude (scale on right) of large events ($M_L \geq 4.0$). Note that the vertical scales of the plots may not be the same.

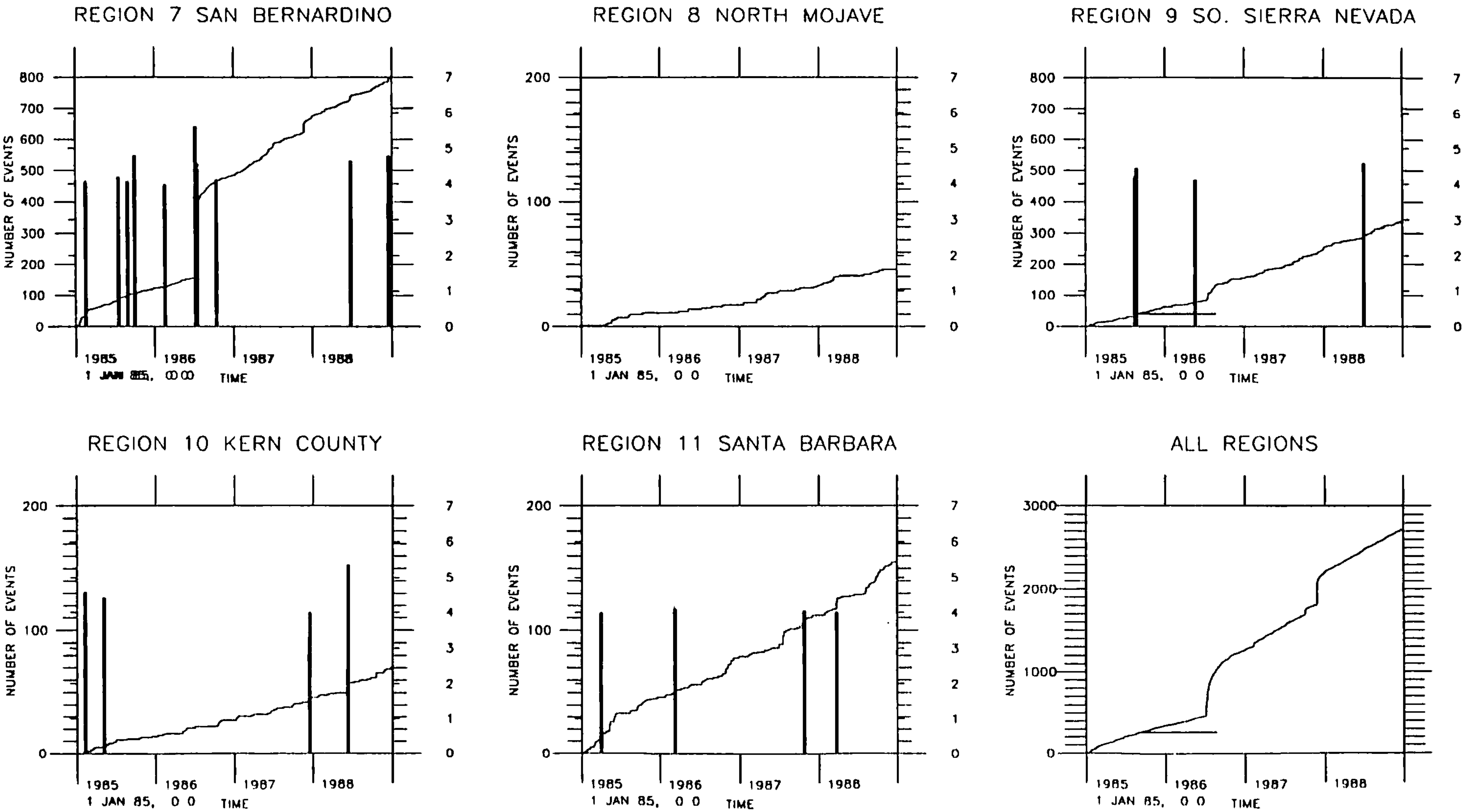

Figure 9b. Cumulative number of events ($M_L \geq 2.5$) in sub-regions 7 through 11 and for all sub-regions over the four year period ending December 1988. The boundaries of the sub-regions are shown in Figure 7. Vertical bars represent time and magnitude (scale on right) of large events ($M_L \geq 4.0$). Note that the vertical scales of the plots may not be the same.

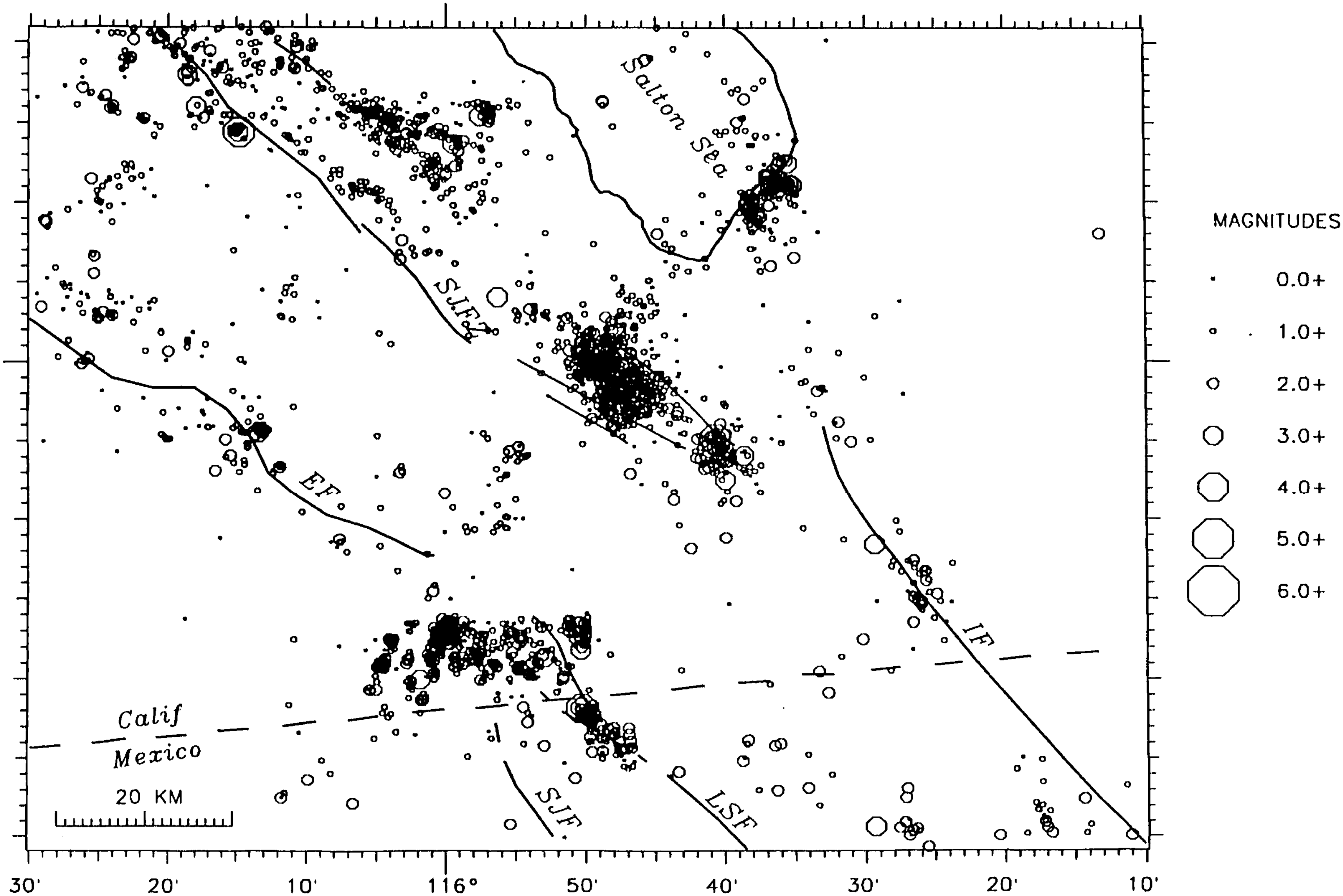

Figure 10. Map of earthquake activity in the California-Mexico border region for the period January through December 1988.

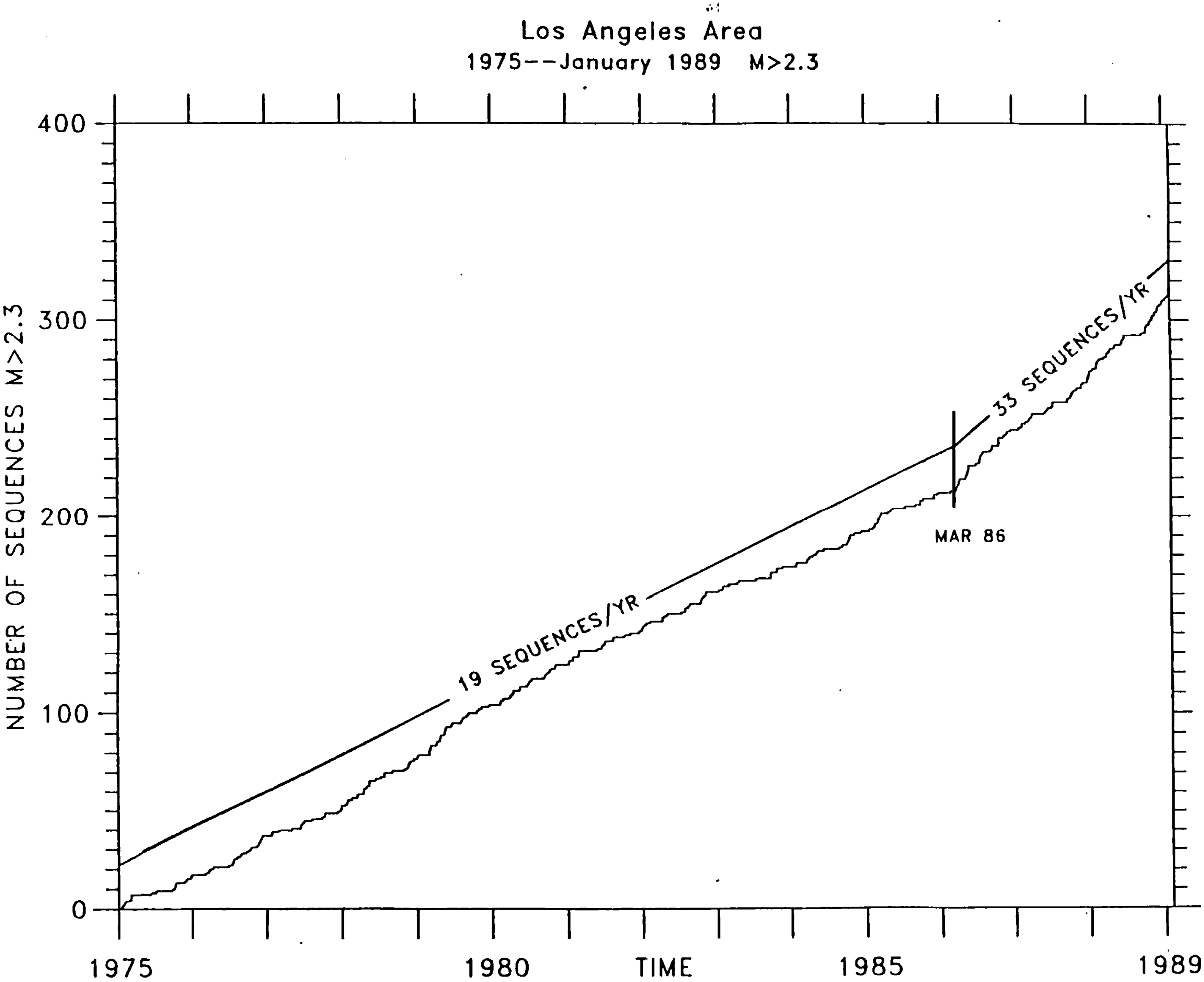

Figure 11. The cumulative number of earthquake sequences of $M \geq 2.3$ recorded within 40 km of 34° 0′ N, 118° 20′ W, versus time.

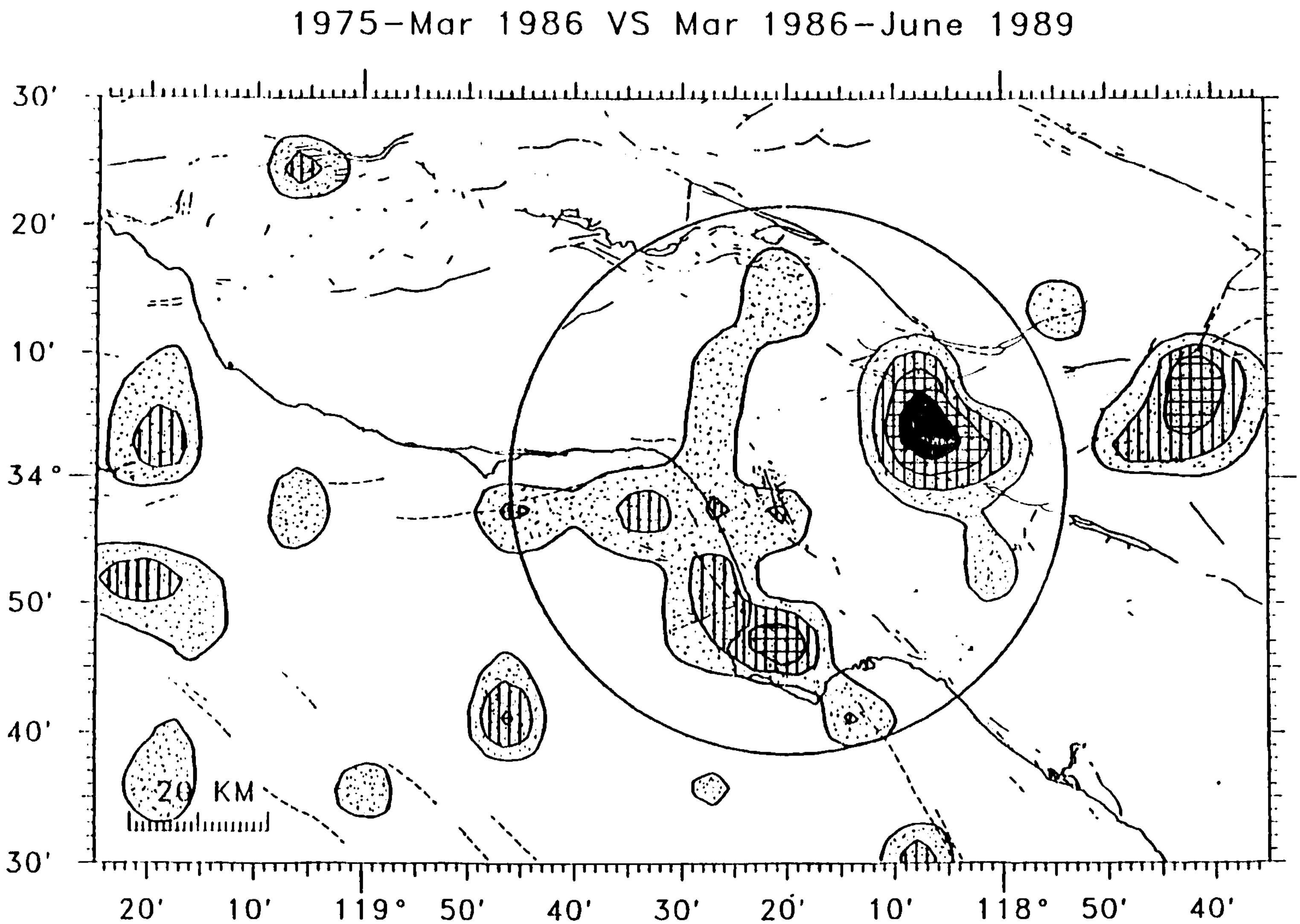

Figure 12. Contours of the ratio of the rates of seismicity ($M \geq 2.3$) from January 1, 1975 to March 1, 1986 and from March 1, 1986 to June 30, 1989. Each contour represents a 50% increase in the number of earthquakes/yr/km^2 between 3/1/86 and 6/30/89 as compared to the earlier time period, 1/1/75–3/1/86.

APPENDIX A.

INSTRUMENT RESPONSE CHARACTERISTICS FOR ACTIVE SITES

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
ABL	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
ADL	1.0	0.8	1.0	J512M	105.0	4.05	30	J120	2.2	125
AMS	1.0	0.8	1.0	J3	100.0	2.70	6	J101M	2.2	125
ARV	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
BAR	1.0	0.8	1.0	CIT	115.0	13.20	14	J120	2.2	125
BAT	1.0	0.8	1.0	J512M	105.0	4.05	24	J120	2.2	125
BC2	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
BCH	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
BLK	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
BMT	1.0	0.8	1.0	J3	100.0	2.70	6	J120	2.2	125
BON	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
BOO	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
BRAZ	1.0	0.8	3.4	J4X	100.0	2.70	36	J120	2.2	125
BRG	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
BRT	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
BTL	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
CAL	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
CAV	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
CBK	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
CFL	1.0	0.8	1.0				6	J120	2.2	125
CFT	1.0	0.8	1.0	J512M	105.0	4.05	30	J120	2.2	125
CH2	1.0	0.8	1.0	J5M	115.0	4.05	6	J120	2.2	125
CIS	1.0	0.8	1.0	J1	100.0	2.70	24	J120	2.2	125
CIW	1.0	0.7	1.0	KIN			30	J120	2.2	125
CJV	1.0	0.8	1.0	J512M	115.0	4.05	24	J120	2.2	125
CLC	1.0	0.8	1.0					J120	2.2	125
CLI	1.0	0.8	1.0	J1	100.0	2.70	36	J120	2.2	125
CLIE	1.0	0.8	1.0	J2	100.0	2.70	42	J120	2.2	125
CLIN	1.0	0.8	1.0	J2	100.0	2.70	42	J120	2.2	125
CO2	1.0	0.8	1.0	J1	100.0	2.70	6	J120	2.2	125
COA	1.0	0.8	1.0	J2	100.0	2.70	24	J120	2.2	125
COK	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
COY	1.0	0.8	1.0	J2	100.0	2.70	6	J120	2.2	125
COYZ	1.0	0.8	1.0	J412HX	105.0	4.05	24	J120	2.2	125
CPE	1.0	0.8	1.0	CIT	105.0	12.00	14	J120	2.2	125
CPM	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
CPMZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
CRG	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
CRR	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
CTW	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
CTWZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
DB2	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
DBM	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
DTP	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
ECF	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125

APPENDIX A.

(continued)

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
EDWI	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
EDWJ	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
EDWK	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
EDWZ	1.0	0.8	1.0	J412HX	105.0	4.05	24	J120	2.2	125
ELM	1.0	0.8	1.0	J512M	105.0	4.05	24	J120	2.2	125
ELR	1.0	0.8	1.0	J512M	105.0	4.05	36	J120	2.2	125
ELS	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
EMS	1.0	0.8	1.0	J3	100.0	2.70	24	J120	2.2	125
ERP	1.0	0.8	1.0	J412H	105.0	4.05	30	J120	2.2	125
EWC	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
EWCE	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
EWCN	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
EWCZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
FIL	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
FLS	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
FOX	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
FRG	1.0	0.8	1.0	J5M	115.0	4.05	12	J120	2.2	125
FRK	1.0	0.8	1.0	J512M	115.0	4.05	18	J120	2.2	125
FTC	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
GAV	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
GAVZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
GFPZ	1.0	0.9	2.9	KIN			36	J120	2.2	125
GLA	1.0	0.8	1.0	CIT	115.0	13.50	8	J120	2.2	125
GLAE	1.0	0.8	1.0	CIT	115.0	13.50	26	J120	2.2	125
GLAN	1.0	0.8	1.0	CIT	115.0	13.50	26	J120	2.2	125
GRP	1.0	0.8	1.0	J2	100.0	2.70	6	J120	2.2	125
GSAA	0.0	0.0	5.0							
GSAB	0.0	0.0	5.0							
GSAC	0.0	0.0	5.0							
GSAI	0.0	0.0	2.5							
GSAJ	0.0	0.0	2.5							
GSAK	0.0	0.0	2.5							
GSC	1.0	0.8	1.0	CIT	115.0	13.20	2	J120	2.2	125
GVR	1.0	0.8	1.0	J4	100.0	2.70	42	J120	2.2	125
GVRE	1.0	0.8	1.0	J4X	100.0	2.70	30	J120	2.2	125
GVRI	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
GVRJ	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
GVRK	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
GVRN	1.0	0.8	1.0	J4X	100.0	2.70	30	J120	2.2	125
HAY	1.0	0.8	1.0	CIT	115.0	12.00	14	J120	2.2	125
HDG	1.0	0.8	1.0	J4	100.0	2.70	6	J101M	2.8	125
HOD	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
HOT	1.0	0.8	1.0	J2	100.0	2.70	6	J120	2.2	125
HYS	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
IKP	1.0	0.8	1.0	CIT	105.0	13.20	20	J120	2.2	125

APPENDIX A.

(continued)

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
IND	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
ING	1.0	0.8	1.0	J2	100.0	2.70	36	J120	2.2	125
INS	1.0	0.8	1.0	J5M	115.0	4.05	12	J120	2.2	125
IRN	1.0	0.8	1.0	J4	100.0	2.70	6	J110	2.2	125
IRS	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
ISA	1.0	0.8	1.0	CIT	115.0	13.20	2	J120	2.2	125
ISAE	1.0	0.8	1.0	CIT	125.0	13.50	20	J120	2.2	125
ISAN	1.0	0.8	1.0	CIT	125.0	13.50	20	J120	2.2	125
JAW	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
JFS	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
JNH	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
JUL	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.5	125
KEE	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
KYP	1.0	0.8	1.0	J1	100.0	2.70	12	J120	2.2	125
LAQ	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
LAV	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
LED	1.0	0.8	1.0	J4	100.0	2.70	12	J101M	2.8	125
LEO	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
LHU	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
LJB	1.0	0.8	1.0	J2	100.0	2.70	6	J120	2.2	125
LJBE	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
LJBN	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
LJBZ	1.0	0.8	1.0	J2X	100.0	2.70	24	J120	2.2	125
LLN	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
LOK	1.0	0.8	1.0	J1	100.0	2.70	18	J120	2.2	125
LRM	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
LRR	1.0	0.8	1.0	J2	100.0	2.70	24	J120	2.2	125
LTC	1.0	0.8	1.0	J1	100.0	2.70	12	J120	2.2	125
LUC	1.0	0.8	1.0	J4	100.0	2.70	36	J120	2.2	125
MAR	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
MDA	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
MEC	1.0	0.8	1.0	J5M	115.0	4.05	12	J120	2.2	125
MIR	1.0	0.8	1.0	J512M	115.0	4.05	24	J120	2.2	125
MLL	1.0	0.8	1.0	J1	100.0	2.70	24	J120	2.2	125
MWC	1.0	0.8	1.0	CIT	125.0	13.50	14	J120	2.2	125
NW2	1.0	0.8	1.0	J512M	105.0	4.05	42	J120	2.2	125
OLY	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
ORK	1.0	0.8	1.0	J5M	115.0	4.05	12	J120	2.2	125
PCF	1.0	0.8	1.0	J1	100.0	2.70	36	J120	2.2	125
PEM	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
PEMZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
PKM	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
PLE	1.0	0.8	1.0	J512M	105.0	4.05	30	J120	2.2	125
PLM	1.0	0.8	1.0	CIT	105.0	13.20	14	J120	2.2	125
PLT	1.0	0.8	1.0	J1	100.0	2.70	12	J120	2.2	125

APPENDIX A.

(continued)

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
PNM	1.0	0.8	1.0	J4	100.0	2.70	12	J110	2.0	125
POB	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
POBZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
PSP	1.0	0.8	1.0	J3	100.0	2.70	30	J120	2.2	125
PTD	1.0	0.8	1.0	J2	100.0	2.70	36	J120	2.2	125
PVR	1.0	0.8	1.0	J4	100.0	2.70	30	J120	2.2	125
QAL	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
RAY	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
RAYZ	1.0	0.8	1.0	J4X	100.0	2.70	24	J120	2.2	125
RMR	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
RUN	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
RYS	1.0	0.8	1.0	J512M	105.0	4.05	18	J120	2.2	125
SAD	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
SBB	1.0	0.8	1.0	CIT	105.0	12.00	14	J120	2.2	125
SBK	1.0	0.8	1.0	J512M	105.0	4.05	24	J120	2.2	125
SBPI	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
SBPJ	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
SBPK	0.0	0.0	5.0		125.0	2.50	0	J120	2.2	125
SBPZ	1.0	0.8	3.4	J4X	100.0	2.70	24	J120	2.2	125
SCC	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
SCD	1.0	0.8	1.0	J2	100.0	2.70	24	J120	2.2	125
SCI	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
SDW	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.2	125
SGL	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
SHH	1.0	0.8	1.0	J4	100.0	2.70	6	J110	2.2	125
SIL	1.0	0.8	1.0	J512M	115.0	4.05	18	J120	2.2	125
SILZ	1.0	0.8	1.0	J412HX	105.0	4.05	24	J120	2.2	125
SIM	1.0	0.8	1.0	J512A	105.0	4.05	24	J120	2.2	125
SIP	1.0	0.8	1.0	J5M	115.0	4.05	18	J120	2.2	125
SLC	1.0	0.8	1.0	J2	100.0	2.70	24	J120	2.2	125
SLG	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
SLP	1.0	0.8	1.0	J1	100.0	2.70	24	J120	2.2	125
SME	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
SMO	1.0	0.8	1.0	J512M	115.0	4.05	24	J120	2.2	125
SND	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
SNR	1.0	0.8	1.0	J4	100.0	2.70	36	J120	2.2	125
SNRE	1.0	0.8	1.0	J3	100.0	2.70	36	J120	2.2	125
SNS	1.0	0.8	1.0	CIT	115.0	12.00	20	J120	2.2	125
SPM	1.0	0.8	1.0	J4	100.0	2.70	0	J110	2.0	125
SRT	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
SS2	1.0	0.8	1.0	J512M	105.0	4.05	24	J120	2.2	125
SSC	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
SSM	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
SSN	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
STT	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125

APPENDIX A.

(continued)

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
SUN	1.0	0.8	1.0	J5M	115.0	4.05	24	J120	2.2	125
SUP	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
SWM	1.0	0.8	1.0	CIT	125.0	13.50	2	J120	2.2	125
SYP	1.0	0.8	1.0	CIT	115.0	13.20	26	J120	2.2	125
SYS	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
TAB	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
TABZ	1.0	0.8	1.0	J4X	100.0	2.70	30	J120	2.2	125
TCC	1.0	0.8	1.0	J1	100.0	2.70	30	J120	2.2	125
TEJ	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
THC	1.0	0.8	1.0	J512M	105.0	4.05	24	J120	2.2	125
TJR	1.0	0.8	1.0	J1	100.0	2.70	12	J120	2.2	125
TMB	1.0	0.8	1.0	J512M	105.0	4.05	30	J120	2.2	125
TOW	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
TPC	1.0	0.8	1.0	CIT	115.0	13.20	14	J120	2.2	125
TPO	1.0	0.8	1.0	J3	100.0	2.70	12	J120	2.2	125
TWL	1.0	0.8	1.0	CIT	115.0	13.20	20	J120	2.2	125
VG2	1.0	0.8	1.0	J512M	115.0	4.05	24	J120	2.2	125
VPD	1.0	0.8	1.0	CIT	115.0	12.00	20	J120	2.2	125
VST	1.0	0.8	1.0	CIT	115.0	12.00	14	J120	2.2	125
WAS	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
WBM	1.0	0.8	1.0	J4	100.0	2.70	24	J120	2.2	125
WBS	1.0	0.8	1.0	J3	100.0	2.70	18	J120	2.2	125
WCH	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
WCS	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
WHF	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
WHV	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
WIS	1.0	0.8	1.0	J512M	115.0	4.05	36	J120	2.2	125
WISE	1.0	0.8	1.0	J2	100.0	2.70	48	J120	2.2	125
WJP	1.0	0.8	1.0	J3	100.0	2.70	12	J120	2.2	125
WKT	1.0	0.8	1.0	J3	100.0	2.70	24	J110	3.0	125
WLH	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
WMF	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
WNM	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
WOF	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
WOR	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
WRC	1.0	0.8	1.0	J2	100.0	2.70	6	J120	2.2	125
WRV	1.0	0.8	1.0	J412H	105.0	4.05	12	J120	2.2	125
WSC	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
WSH	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125
WSP	1.0	0.8	1.0	J4	100.0	2.70	18	J120	2.2	125
WVP	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
WWP	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
WWR	1.0	0.8	1.0	J2	100.0	2.70	24	J120	2.2	125
XMS	1.0	0.8	1.0	J2	100.0	2.70	12	J120	2.2	125
XTL	1.0	0.8	1.0	J512M	105.0	4.05	12	J120	2.5	125

APPENDIX A.

(continued)

SITE CODE	SEIS. FREQ.	DAMP. CON.	GEN. CON.	VCO TYPE	VCO HZ	VCO VOLT	GAIN	DISC. TYPE	DISC. VOLT.	DISC. HZ
YAQ	1.0	0.8	1.0	J4	100.0	2.70	12	J120	2.2	125
YEG	1.0	0.8	1.0	J1	100.0	2.70	18	J120	2.2	125
YMD	1.0	0.8	1.0	J2	100.0	2.70	18	J120	2.2	125
YUH	1.0	0.8	1.0	J4	100.0	2.70	6	J120	2.2	125

Note : Stations for which the full instrument response is not available are not included in this list.

APPENDIX B.

NETWORK CONFIGURATION DATABASE

MAIN

Field	Field Name	Type	Width	Dec
1	STA_CODE	Character	6	
2	STA_NAME	Character	20	
3	STA_N	Numeric	4	
4	DATE	Date	8	
5	LAT_D	Numeric	3	
6	LAT_M	Numeric	6	2
7	LON_D	Numeric	3	
8	LON_M	Numeric	6	2
9	ELEV	Numeric	5	
10	CO	Character	2	
11	AGEN	Character	4	
12	CODE2	Character	6	
13	OFF	Character	3	
14	NOTES	Memo	10	
	Total		87	

SEIS

Field	Field Name	Type	Width	Dec
1	STA_N	Numeric	4	
2	STA_CODE	Character	6	
3	DATE	Date	8	
4	SEIS_TYPE	Character	8	
5	S_SER	Character	4	
6	S_VAL	Numeric	4	
7	T_VAL	Numeric	4	
8	V_POS	Numeric	3	1
9	V_NEG	Numeric	3	1
10	GEN_CON	Numeric	4	1
11	SF	Numeric	3	1
12	DP	Numeric	3	1
13	OFF	Character	3	
	Total		58	

POW

Field	Field Name	Type	Width	Dec
1	STA_N	Numeric	4	
2	STA_CODE	Character	6	
3	DATE	Date	8	
4	VCO_TYPE	Character	5	
5	VCO_DATE	Date	8	
6	SITE_POW	Character	1	
7	POW_DATE	Date	8	
8	OFF	Character	3	
	Total		44	

APPENDIX B.

(continued)

VCO_DISC

Field	Field Name	Type	Width	Dec
1	STA_N	Numeric	4	
2	STA_CODE	Character	6	
3	DATE	Date	8	
4	DISC_TYPE	Character	8	
5	D_SER	Character	5	
6	D_SLOT	Numeric	3	
7	D_VOLT	Numeric	3	1
8	D_HZ	Numeric	3	
9	VCO_TYPE	Character	5	
10	V_HZ	Numeric	5	1
11	V_VOLT	Numeric	5	2
12	V_GAIN	Numeric	3	1
13	ATT	Character	3	
14	OFF	Character	3	
	Total		65	

COMM

Field	Field Name	Type	Width	Dec
1	STA_N	Numeric	4	
2	STA_CODE	Character	6	
3	DATE	Date	8	
4	RX_SITE	Character	15	
5	JK	Numeric	2	
6	CIRCUIT	Character	12	
7	FREQ	Numeric	5	
8	RF	Character	3	
9	PIN	Numeric	3	
10	CNT_VOLT	Numeric	6	1
11	OFF	Character	3	
	Total		68	

POL

Field	Field Name	Type	Width	Dec
1	STA_CODE	Character	6	
2	STA_N	Numeric	4	
3	DATE	Date	8	
4	POL	Character	1	
5	OFF	Character	3	
	Total		23	

APPENDIX C.

SIGNIFICANT SOUTHERN CALIFORNIA EARTHQUAKES

All events of $M_L \geq 3.0$ for the period January to June 1988. Times are GMT, RMS is the root-mean-squared of the location error, NPH is the number of phases picked. The CUSPID is the unique number assigned to the event by the CUSP system. FM denotes the number of the accompanying focal mechanism in Figure 6.

DATE	TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988 JAN 2	19:40	53.06	34.1756	-116.4115	2.87	A	3.5	M_L	0.09	65	740174	1
1988 JAN 2	19:43	0.96	34.1791	-116.4085	2.34	A	3.1	M_L	0.07	25	740175	
1988 JAN 2	23:14	52.77	32.6909	-115.9744	1.36	A	3.1	M_L	0.07	26	740196	
1988 JAN 3	2:02	21.29	36.0919	-117.8597	4.49	A	3.1	M_L	0.05	40	740204	
1988 JAN 3	15:47	15.75	33.0322	-117.8588	6.00	C	3.1	M_L	0.21	37	740241	
1988 JAN 4	11:07	13.82	32.7259	-115.4435	2.93	A	3.0	M_{CA}	0.26	15	135435	
1988 JAN 4	13:09	41.57	32.9564	-115.8116	3.72	A	3.0	M_{CA}	0.08	38	740300	
1988 JAN 5	7:30	56.30	32.9968	-115.8112	1.45	A	3.0	M_L	0.10	31	135434	
1988 JAN 5	9:03	13.24	33.0704	-117.8596	6.00	C	3.8	M_L	0.37	62	740353	2
1988 JAN 17	16:17	44.20	33.0467	-117.7852	6.00	C	3.1	M_L	0.18	30	741224	
1988 JAN 18	1:40	5.96	32.6896	-115.8827	1.79	A	3.2	M_L	0.07	22	135598	
1988 JAN 19	23:15	32.12	34.0728	-118.0615	13.43	A	3.5	M_L	0.21	79	741406	3
1988 JAN 22	:52	20.71	33.8159	-117.0326	15.33	A	3.5	M_L	0.14	86	741602	4
1988 JAN 23	:55	12.20	35.3907	-117.8159	8.23	A	3.1	M_L	0.13	55	741703	
1988 JAN 25	13:22	25.92	32.0490	-116.2969	6.00	C	3.0	M_L	0.13	4	139771	
1988 JAN 28	1:44	57.02	33.2282	-115.9917	0.12	A	3.2	M_L	0.17	47	742121	
1988 JAN 28	2:54	2.34	32.9193	-115.6783	3.74	A	4.7	M_L	0.14	75	742130	5
1988 FEB 1	6:09	17.64	35.3719	-118.8124	13.59	A	3.2	M_L	0.11	37	742397	
1988 FEB 3	9:19	0.41	36.2465	-120.8286	6.00	C	3.0	M_{CA}	0.05	17	742537	
1988 FEB 5	6:58	43.87	32.0110	-116.2335	6.00	C	3.4	M_L	0.24	32	742643	
1988 FEB 6	8:06	3.26	33.9094	-116.9922	15.77	A	3.5	M_L	0.09	82	742741	6
1988 FEB 6	11:29	44.16	36.1102	-120.0183	6.00	C	3.1	M_L	0.31	17	742749	
1988 FEB 10	17:24	53.86	35.9421	-116.7326	6.00	C	3.1	M_{CA}	0.30	13	743011	
1988 FEB 11	15:25	55.65	34.0772	-118.0474	12.50	A	4.7	M_L	0.16	134	743060	7
1988 FEB 15	4:28	40.97	34.6139	-118.6564	8.88	A	3.1	M_L	0.15	92	743284	
1988 FEB 17	23:56	51.45	33.2645	-116.0911	3.06	A	3.4	M_{CA}	0.17	44	743488	
1988 FEB 20	5:19	22.39	33.7601	-116.1084	7.67	A	3.2	M_L	0.05	37	743770	
1988 FEB 20	8:39	57.47	36.7977	-121.3552	6.00	D	4.6	M_L	0.79	19	743779	
1988 FEB 22	7:43	13.88	35.5460	-119.6763	6.00	C	4.2	M_L	0.47	82	743909	8
1988 FEB 23	:48	42.37	36.0377	-114.7243	6.00	D	3.9	M_L	0.30	38	743992	
1988 FEB 28	5:02	59.54	32.6289	-115.8281	7.37	A	3.3	M_L	0.15	43	135805	
1988 FEB 28	5:03	56.34	32.6280	-115.8272	5.94	B	3.1	M_L	0.11	28	744400	
1988 FEB 28	5:04	59.03	32.6180	-115.8205	6.00	C	3.1	M_L	0.24	9	744401	
1988 FEB 28	5:25	2.56	32.6279	-115.8274	6.00	C	3.7	M_L	0.22	37	744409	9
1988 FEB 28	5:39	15.36	32.6307	-115.8284	6.40	A	3.3	M_L	0.07	25	744413	
1988 FEB 28	7:52	52.29	32.6359	-115.8383	6.96	A	4.1	M_L	0.12	50	744432	10
1988 FEB 28	7:56	11.30	32.6368	-115.8393	6.60	A	3.6	M_L	0.11	38	744433	11
1988 FEB 28	7:58	23.08	32.6343	-115.8383	6.69	A	3.0	M_L	0.08	26	744434	
1988 FEB 29	15:25	6.90	34.0317	-116.2461	5.46	A	3.1	M_L	0.10	46	135912	
1988 MAR 1	13:43	52.47	33.2575	-115.9599	1.00	A	3.0	M_L	0.17	45	744670	

DATE	TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988 MAR 3	7:33	55.75	36.9147	-114.4803	6.00	C	3.3	M_{CA}	0.24	24	744880	
1988 MAR 4	2:32	41.09	32.9477	-115.7230	7.91	A	3.0	M_L	0.09	31	744985	
1988 MAR 10	2:00	21.33	34.9392	-116.6997	0.38	A	3.3	M_L	0.11	48	745370	
1988 MAR 14	: 9	13.92	35.4048	-117.7916	8.92	A	3.4	M_L	0.12	52	745687	
1988 MAR 15	16:41	23.45	35.4471	-119.7355	6.00	C	3.0	M_L	0.28	13	745782	
1988 MAR 17	11:00	53.95	36.1665	-114.4262	6.00	C	3.1	M_{CA}	0.42	17	745908	
1988 MAR 21	6:38	9.07	32.0290	-115.4970	6.00	D	3.8	M_L	0.62	41	746196	
1988 MAR 21	11:01	16.65	32.0806	-115.5016	6.00	C	3.1	M_L	0.55	32	746204	
1988 MAR 22	12:37	5.12	35.7843	-117.6323	4.52	A	3.0	M_{CA}	0.11	32	746284	
1988 MAR 23	8:42	46.96	34.2495	-119.6221	17.65	A	4.0	M_L	0.29	112	136023	12
1988 MAR 23	8:57	2.82	34.2560	-119.6321	14.10	A	3.2	M_L	0.20	39	746349	
1988 MAR 24	17:56	35.38	32.2533	-115.2484	6.00	C	3.4	M_{CA}	0.55	24	746453	
1988 MAR 24	20:20	46.52	32.9408	-115.8257	5.36	A	3.0	M_L	0.18	10	136066	
1988 MAR 26	14:54	20.44	33.9963	-118.7104	13.84	A	3.8	M_L	0.14	135	636787	13
1988 MAR 26	21:20	44.79	36.0598	-120.0469	6.00	C	3.2	M_L	0.40	19	746599	
1988 APR 1	18:52	53.40	32.9262	-116.2230	9.21	A	3.6	M_L	0.10	62	747068	14
1988 APR 2	23:43	1.16	32.9247	-117.7304	6.00	C	3.2	M_L	0.38	45	747156	
1988 APR 3	3:34	4.66	32.9214	-117.7301	6.00	C	3.3	M_L	0.29	37	747173	
1988 APR 4	2:01	18.53	32.9212	-117.7231	6.00	C	3.3	M_L	0.32	24	747221	
1988 APR 4	20:42	0.07	36.3281	-120.3553	6.00	C	4.2	M_L	0.21	35	747261	
1988 APR 4	20:45	47.79	36.3418	-120.3591	6.00	C	3.8	M_L	0.22	35	747262	
1988 APR 4	21:28	0.36	32.3659	-115.3391	6.00	C	3.0	M_L	0.27	19	747264	
1988 APR 5	11:48	43.66	32.9545	-117.7149	6.00	C	3.0	M_L	0.30	23	747306	
1988 APR 5	14:38	32.01	32.6669	-116.0309	6.00	C	3.9	M_L	0.26	48	747317	15
1988 APR 6	2:36	56.95	34.9703	-116.5342	6.00	C	3.2	M_L	0.11	57	747378	
1988 APR 12	13:21	57.47	32.7258	-115.9962	3.45	A	3.0	M_L	0.12	34	747840	
1988 APR 13	6:52	39.78	33.0023	-117.7939	6.00	C	3.2	M_L	0.25	9	747934	
1988 APR 14	13:03	9.35	33.2671	-116.2988	10.66	A	3.1	M_L	0.10	43	748013	
1988 APR 15	8:09	32.37	32.5108	-115.4888	14.84	A	3.0	M_L	0.17	21	748122	
1988 APR 18	7:12	41.15	35.6850	-117.4989	10.52	A	3.6	M_L	0.11	60	748349	16
1988 APR 19	6:42	48.14	36.7320	-120.6443	6.00	D	3.7	M_L	0.28	13	638012	
1988 APR 20	14:23	52.91	36.4944	-121.1212	6.00	C	3.4	M_L	0.34	15	638081	
1988 APR 21	1:43	39.37	32.8068	-115.4895	6.00	D	3.2	M_L	0.56	10	136323	
1988 APR 21	8:14	47.52	33.4131	-117.0706	6.00	C	3.2	M_L	0.20	16	136324	
1988 APR 23	16:57	31.01	36.2316	-120.1936	6.00	C	3.1	M_L	0.40	31	638315	
1988 APR 24	12:13	39.07	32.9014	-115.6438	5.69	C	3.2	M_L	0.19	41	638350	
1988 APR 28	6:16	7.85	35.5851	-116.2880	6.00	C	3.7	M_L	0.35	67	638522	
1988 APR 29	5:29	14.77	34.0270	-116.7646	11.93	A	3.6	M_L	0.10	93	1000432	17
1988 MAY 1	22:42	49.29	32.9876	-117.8708	6.00	C	3.8	M_L	0.43	59	638726	18
1988 MAY 2	1:37	8.63	33.0047	-117.8707	6.00	C	3.1	M_L	0.33	30	638730	
1988 MAY 2	19:23	27.66	36.7020	-121.3920	6.00	D	3.0	M_{CA}	0.18	11	638753	

APPENDIX C. (continued)

DATE	TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988 MAY 4	:21	28.62	36.7365	-120.6815	6.00	C	3.5	M_L	0.37	22	638794	
1988 MAY 8	20:51	26.62	36.4697	-121.0891	6.00	C	3.4	M_L	0.20	12	639040	
1988 MAY 10	12:31	31.28	36.8073	-121.6344	6.00	D	3.0	M_{CA}	0.71	12	639103	
1988 MAY 13	:54	48.49	36.6113	-118.0892	6.00	C	3.1	M_L	0.15	35	639253	
1988 MAY 15	17:53	51.08	34.1149	-117.4699	9.32	A	3.3	M_L	0.11	88	639366	
1988 MAY 16	16:45	50.88	34.0275	-116.7619	11.54	A	3.1	M_L	0.10	73	639407	
1988 MAY 17	19:38	37.96	33.2405	-116.2470	8.34	A	4.2	M_L	0.14	73	639478	19
1988 MAY 23	5:23	48.95	32.7207	-115.9999	1.93	A	3.4	M_L	0.14	44	639755	
1988 MAY 24	7:55	26.75	34.0047	-116.7800	14.96	A	3.4	M_L	0.11	87	639811	
1988 MAY 28	10:51	13.33	35.9896	-114.7944	6.00	C	3.6	M_L	0.32	23	640023	
1988 MAY 30	16:05	10.62	36.4455	-117.8523	6.00	C	3.7	M_L	0.21	56	640128	20
1988 MAY 30	17:28	18.45	36.4406	-117.8573	6.00	C	3.9	M_L	0.22	66	640132	21
1988 JUN 4	:31	57.23	33.9777	-117.1161	16.55	A	3.6	M_L	0.12	112	640380	22
1988 JUN 6	8:06	26.20	33.2999	-116.3096	12.85	A	3.2	M_L	0.13	46	640433	
1988 JUN 9	3:23	43.53	36.2108	-120.2700	6.00	C	3.2	M_L	0.16	9	640643	
1988 JUN 10	23:06	43.05	34.9430	-118.7427	6.81	A	5.4	M_L	0.17	119	640798	23
1988 JUN 10	23:22	11.02	34.9373	-118.7537	5.96	A	3.6	M_L	0.19	81	640800	24
1988 JUN 11	1:54	21.53	34.9375	-118.7366	5.35	A	3.1	M_L	0.21	100	640822	
1988 JUN 11	8:41	20.50	34.9365	-118.7543	6.00	A	3.0	M_L	0.17	65	640844	
1988 JUN 12	21:22	2.65	34.0355	-117.5570	8.35	A	3.2	M_L	0.16	110	640924	
1988 JUN 13	19:28	42.00	32.4837	-115.4367	6.00	C	3.0	M_L	0.31	31	640985	
1988 JUN 17	5:33	38.91	33.2406	-116.2481	8.44	A	3.2	M_L	0.13	52	641229	
1988 JUN 18	10:05	37.13	35.9944	-118.8962	6.00	C	3.2	M_L	0.08	33	641333	
1988 JUN 18	10:25	21.60	33.9100	-116.9454	15.57	A	3.1	M_L	0.09	59	641334	
1988 JUN 18	13:22	25.69	33.9104	-116.9464	15.29	A	3.5	M_L	0.10	85	641338	25
1988 JUN 18	20:06	11.16	36.2818	-120.2885	6.00	C	3.5	M_L	0.12	20	641394	
1988 JUN 21	20:02	50.47	32.0714	-116.4120	6.00	C	3.8	M_L	0.24	32	641582	
1988 JUN 24	6:31	2.44	33.9763	-116.3241	2.80	A	3.0	M_L	0.11	46	641747	
1988 JUN 25	17:48	25.62	33.7826	-115.9819	8.70	A	3.2	M_L	0.11	55	136981	
1988 JUN 26	15:04	58.48	34.1362	-117.7095	7.89	A	4.7	M_L	0.16	133	136984	26
1988 JUN 26	15:06	25.65	34.1349	-117.7038	7.16	A	3.2	M_{CA}	0.04	17	641883	
1988 JUN 26	16:09	56.26	34.1382	-117.7023	7.75	A	3.2	M_L	0.11	89	136989	
1988 JUN 26	16:11	44.63	34.1397	-117.7010	8.04	A	3.1	M_L	0.09	58	641889	
1988 JUN 26	18:38	39.87	34.1395	-117.7067	6.44	A	3.3	M_L	0.14	68	641904	
1988 JUN 26	22:43	14.14	33.8014	-116.0531	9.09	A	3.0	M_L	0.06	21	137000	

APPENDIX D.

SIGNIFICANT SOUTHERN CALIFORNIA EARTHQUAKES

All events of $M_L \geq 3.0$ for the period July to December 1988. Times are GMT, RMS is the root-mean-squared of the location error, NPH is the number of phases picked. The CUSPID is the unique number assigned to the event by the CUSP system. FM denotes the number of the accompanying focal mechanism in Figure 6.

DATE			TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988	JUL	2	:26	58.19	33.4832	-116.4386	12.63	A	4.3	M_L	0.13	57	642247	27
1988	JUL	2	5:31	4.11	33.4771	-116.4547	13.43	A	3.3	M_L	0.12	59	642275	
1988	JUL	2	5:31	22.95	33.4613	-116.4715	11.00	C	3.1	M_L	0.13	19	137010	
1988	JUL	3	2:06	1.13	33.9799	-117.0002	18.26	A	3.4	M_L	0.10	85	642337	
1988	JUL	5	18:18	47.88	36.4259	-118.0254	6.00	C	4.6	M_L	0.27	99	642493	28
1988	JUL	6	10:55	5.52	34.1356	-117.7134	8.61	A	3.7	M_L	0.14	116	642561	29
1988	JUL	15	10:57	38.37	32.0679	-116.4146	6.00	C	3.9	M_L	0.33	34	643099	
1988	JUL	20	20:45	45.23	36.4474	-118.0439	6.00	C	3.1	M_L	0.26	37	1006631	
1988	JUL	22	: 9	25.96	36.1876	-120.1108	6.00	C	3.5	M_L	0.41	27	643469	
1988	JUL	27	16:57	40.90	36.5904	-121.1880	6.00	D	3.8	M_L	0.48	18	643703	
1988	JUL	28	11:20	24.67	36.3854	-118.0309	0.43	A	3.6	M_L	0.09	44	643741	
1988	JUL	28	11:33	14.78	36.3839	-118.0308	0.74	A	3.2	M_L	0.10	36	643742	
1988	JUL	29	10:57	46.09	36.2469	-120.3060	6.00	C	3.1	M_L	0.11	20	643779	
1988	JUL	29	14:58	36.31	36.3116	-120.3625	6.00	C	3.3	M_L	0.15	21	643785	
1988	JUL	31	10:26	2.98	36.2056	-120.2376	6.00	C	3.4	M_L	0.14	17	643905	
1988	AUG	6	5:35	12.82	34.5831	-120.7649	6.00	C	3.2	M_L	0.31	21	1007109	
1988	AUG	7	5:43	39.97	36.3487	-120.3988	6.00	C	3.3	M_L	0.12	12	1007134	
1988	AUG	10	18:24	51.20	36.4570	-118.0402	6.00	C	3.7	M_L	0.25	42	644538	30
1988	AUG	10	18:27	2.18	36.4205	-118.0446	6.00	C	3.3	M_L	0.18	32	644539	
1988	AUG	12	14:40	57.16	36.2229	-120.3476	12.90	A	3.8	M_L	0.08	27	1007380	
1988	AUG	20	18:15	27.89	32.5033	-117.9069	6.00	C	4.0	M_L	0.70	85	1007822	
1988	AUG	21	10:06	45.21	36.2083	-120.2132	6.00	C	3.1	M_L	0.22	18	1007860	
1988	AUG	21	11:14	34.21	32.1917	-115.0666	6.00	C	3.1	M_L	0.53	22	1007865	
1988	AUG	25	20:00	36.83	32.6977	-115.8396	5.02	A	3.0	M_L	0.18	39	1008161	
1988	AUG	26	4:57	21.51	34.5277	-116.4285	5.88	C	3.7	M_L	0.12	65	1008181	31
1988	AUG	31	16:23	18.73	33.4294	-118.0158	6.00	C	3.1	M_L	0.19	40	1008436	
1988	SEP	2	4:29	8.45	33.0227	-117.8201	6.00	C	3.0	M_L	0.22	30	1008520	
1988	SEP	2	17:26	2.31	33.5049	-118.0870	14.27	A	3.0	M_L	0.15	24	1008547	
1988	SEP	2	18:12	34.22	32.0046	-116.3818	6.00	C	3.5	M_L	0.16	26	1008550	
1988	SEP	4	2:47	29.84	33.0147	-117.8562	6.00	C	3.2	M_L	0.19	24	1008602	
1988	SEP	4	22:25	30.31	36.2470	-120.2538	6.00	C	3.2	M_L	0.17	12	1008629	
1988	SEP	8	23:16	43.03	35.0895	-118.9622	18.44	A	3.5	M_L	0.17	74	1008799	32
1988	SEP	11	18:12	14.10	33.0131	-117.8013	6.00	C	3.3	M_L	0.29	42	1008935	
1988	SEP	12	13:24	34.21	33.8665	-118.4571	3.37	A	3.9	M_L	0.17	73	1008955	33
1988	SEP	16	5:36	37.92	32.9636	-117.7325	6.00	C	3.1	M_L	0.25	28	1009152	
1988	SEP	17	4:44	30.09	33.0037	-117.8523	6.00	C	3.1	M_L	0.29	29	137716	
1988	SEP	17	15:50	20.23	35.5734	-119.5799	38.67	A	3.2	M_L	0.13	22	1009232	
1988	SEP	22	23:33	17.69	36.5504	-120.6932	6.00	D	3.3	M_L	0.18	16	1009531	
1988	SEP	24	7:33	45.08	34.4357	-120.7896	24.00	C	3.8	M_L	0.23	37	1009620	
1988	SEP	26	10:10	44.07	32.9779	-117.8013	6.00	C	3.2	M_L	0.26	20	1009793	

DATE	TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988 SEP 27	5:19	20.51	34.5775	-116.5783	1.98	A	3.1	M_L	0.11	55	1009871	
1988 SEP 30	7:58	14.35	33.0365	-117.8576	6.00	C	3.4	M_L	0.19	10	137860	
1988 SEP 30	10:08	9.44	32.9794	-117.8574	6.00	C	3.1	M_L	0.49	11	137861	
1988 OCT 1	17:56	27.63	34.2663	-118.3841	11.99	A	3.3	M_{CA}	0.21	71	1010109	
1988 OCT 5	23:37	45.78	33.5755	-116.8031	5.49	A	3.0	M_{CA}	0.10	30	1010453	
1988 OCT 7	9:04	56.54	34.0259	-116.7579	11.71	A	3.0	M_{CA}	0.10	56	1010556	
1988 OCT 8	21:14	20.15	36.1034	-117.8605	6.07	A	3.5	M_{CA}	0.08	56	1010734	43
1988 OCT 8	21:26	6.09	36.1036	-117.8611	6.04	A	3.2	M_{CA}	0.09	36	137972	
1988 OCT 8	21:27	41.46	34.0278	-116.7567	12.11	A	3.1	M_{CA}	0.09	42	1010736	
1988 OCT 9	11:27	0.87	34.5273	-116.4294	6.00	C	3.1	M_{CA}	0.10	47	1010805	
1988 OCT 9	12:47	15.66	34.7362	-117.6725	6.00	A	3.4	M_{CA}	0.11	71	1010808	
1988 OCT 10	20:40	29.50	32.5230	-118.1935	6.00	D	3.6	M_{CA}	0.54	39	1010905	
1988 OCT 17	9:52	59.83	36.7076	-121.4300	6.00	D	3.3	M_{CA}	0.50	13	1011439	
1988 OCT 19	10:50	49.50	34.9360	-118.7626	5.45	A	3.4	M_{CA}	0.08	53	1011609	
1988 OCT 19	13:44	46.33	34.9360	-118.7616	5.95	A	3.8	M_{CA}	0.13	126	1011619	35
1988 OCT 19	14:04	21.99	34.9323	-118.7637	4.89	A	3.2	M_{CA}	0.14	70	1011621	
1988 OCT 19	22:47	54.49	33.1805	-115.6039	0.40	A	3.7	M_{CA}	0.18	45	648343	
1988 OCT 19	22:55	47.59	33.1917	-115.6134	0.02	A	3.4	M_{CA}	0.12	34	138058	
1988 OCT 20	1:56	43.15	33.2076	-115.5924	0.89	A	3.1	M_{CA}	0.20	30	648359	
1988 OCT 23	11:20	50.98	35.7705	-120.3384	7.38	A	3.0	M_{CA}	0.07	26	1012002	
1988 OCT 30	20:02	19.24	34.6048	-120.7210	11.22	A	3.4	M_{CA}	0.18	44	1012473	
1988 NOV 1	3:11	17.29	36.1692	-120.1006	6.00	C	3.2	M_{CA}	0.29	24	1012513	
1988 NOV 5	5:23	22.30	34.3229	-116.8331	5.82	A	3.0	M_{CA}	0.10	104	1012685	
1988 NOV 5	23:50	32.05	34.0409	-117.1883	14.38	A	3.6	M_{CA}	0.15	155	1012698	36
1988 NOV 6	15:26	15.73	34.0447	-116.7732	12.94	A	3.0	M_{CA}	0.13	76	1012709	
1988 NOV 8	4:34	32.99	32.8755	-115.6658	14.00	A	3.2	M_{CA}	0.18	26	1012740	
1988 NOV 17	5:43	6.01	33.4865	-116.4114	8.22	A	3.3	M_{CA}	0.10	70	1013121	
1988 NOV 20	5:29	53.81	33.5102	-118.0691	6.00	C	3.0	M_{CA}	0.26	44	1013253	
1988 NOV 20	5:39	28.67	33.5074	-118.0711	6.00	C	4.5	MH	0.29	104	1013254	37
1988 NOV 21	11:04	30.00	33.7646	-115.9785	4.87	A	3.1	M_{CA}	0.11	33	1013327	
1988 NOV 22	20:23	13.21	34.9634	-118.7585	8.27	A	3.1	M_{CA}	0.15	71	650163	
1988 NOV 23	6:25	30.05	33.0681	-115.9385	2.72	A	3.3	M_{CA}	0.22	50	1013560	
1988 NOV 24	8:17	44.65	33.7640	-115.9798	4.77	A	3.0	M_{CA}	0.10	38	138340	
1988 NOV 25	19:14	52.98	35.8200	-118.3073	9.77	A	3.0	M_{CA}	0.07	30	650347	
1988 NOV 29	15:30	40.79	34.9882	-119.2005	5.09	A	3.0	M_{CA}	0.12	40	1014077	
1988 NOV 30	20:15	37.45	36.3127	-120.4027	6.00	C	3.0	M_{CA}	0.13	17	650611	
1988 DEC 3	11:38	26.44	34.1488	-118.1346	13.34	A	4.9	M_L	0.16	186	650799	38
1988 DEC 4	16:33	43.60	36.1140	-119.9790	6.00	C	3.1	M_{CA}	0.30	22	650863	
1988 DEC 10	17:34	17.06	36.0308	-117.5224	0.00	A	3.1	M_{CA}	0.10	24	1015025	
1988 DEC 15	19:21	10.58	35.6697	-121.7723	6.00	D	3.4	M_{CA}	0.16	17	651382	

DATE	TIME	SEC	LAT	LON	Z	Q	M	TYP	RMS	NPH	CUSPID	FM
1988 DEC 15	23:19	13.89	33.4848	-116.5428	12.82	A	3.0	M_{CA}	0.11	52	651393	
1988 DEC 16	1:50	28.82	36.8241	-121.2576	6.00	D	3.5	M_{CA}	0.46	15	651395	
1988 DEC 16	5:53	5.00	33.9789	-116.6813	8.12	A	4.8	M_L	0.11	169	651401	39
1988 DEC 17	23:46	16.73	33.6867	-118.1407	11.59	A	3.2	M_{CA}	0.25	44	138557	
1988 DEC 19	12:02	1.25	32.0323	-116.2061	6.00	D	3.0	M_{CA}	0.21	12	651594	
1988 DEC 22	2:03	59.57	33.1855	-115.5904	1.00	C	3.1	M_{CA}	0.18	29	651722	
1988 DEC 22	22:21	13.71	36.2238	-120.3215	15.22	A	3.5	M_{CA}	0.07	17	1016177	
1988 DEC 29	3:33	25.00	33.1843	-115.5868	1.00	A	3.0	M_{CA}	0.23	38	1016617	