The 1997 Southern California Seismic Network Bulletin

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INTRODUCTION

The Pasadena Office of the U.S. Geological Survey (USGS), together with the Caltech Seismology Laboratory, operates a network of more than 350 remote seismometers in southern California called the Southern California Seismic Network (SCSN). The SCSN is part of TriNet, a cooperative project between the USGS, Caltech, and the California Division of Mines and Geology (CDMG). TriNet will upgrade the existing network to digital recording, add new stations, and develop real-time and early-warning capabilities. Signals from the SCSN sites are telemetered to a central processing location at the Caltech Seismology Lab 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 analysts and archived along with digital seismograms. Data acquisition, processing, and archiving are achieved using the Caltech/USGS Seismic Processing (CUSP) system (Dollar, 1989). These data have been compiled into the SCSN Catalog of Earthquakes, a list beginning in 1932 that currently contains more than 300,000 events. Waveform, phase, and catalog data are archived by the Southern California Earthquake Center Data Center (SCEC_DC). This data set is critical to the evaluation of earthquake hazards in California and to the advancement of geoscience as a whole.

This and previous SCSN Bulletins are intended to serve several purposes, the most important of which is to make Network data more accessible to current and potential users. The Bulletins also document important details of Network operation so that researchers can use the data with a full understanding of the process by which they are collected.

SCSN/TriNet: THE SEISMIC SYSTEM FOR SOUTHERN CALIFORNIA

The SCSN is changing. The SCSN has entered into a partnership with the CDMG to upgrade and integrate the products of both the SCSN and the State of California's Strong Motion Instrumentation Program. This project, called TriNet, combines the capabilities of older strong-motion and seismographic networks. Ground motions of all sizes, from the background noise caused by trucks to the strongest shaking in a great earthquake, are recorded on-scale by a single network. Records are sent to central computers in either real time or within minutes, processed within minutes, and sent on to those who can utilize the information to protect public safety.

TriNet has received funding from many agencies and corporate partners interested in improving public safety in southern California. Major funding has been received from hazard mitigation funds allocated by the Federal Emergency Management Agency and administered by the California Office of Emergency Services after the 1994 Northridge earthquake. In addition, the USGS and the CDMG have committed their internal funds to support the project, as have several corporate partners through Caltech, including Pacific Bell, GTE, and Sun Microsystems.

To guide our operations during this upgrade, the SCSN is developing a system specification document for the new network that states the mission and goals of the project. The present timetable calls for complete implementation before 2003. The mission statement and goals from this document are presented below and comments and discussion are welcome (jones@gps.caltech.edu).

Mission Statement

The Caltech/USGS element of TriNet (SCSN/TriNet), in cooperation with other agencies, will record and analyze earthquake ground motions in southern California, and rapidly disseminate that information, to improve our understanding of earthquakes and their effects, to contribute to the improvement of building codes and structural design, and to facilitate emergency response.

Goals

To achieve this mission, SCSN/TriNet is pursuing the following goals.

A. Seismographic network. Operate a hardened seismographic network to record earthquake ground motions in southern California.

1. Record all ground motions at all frequencies of seismological and engineering interest, from the largest ground motions during major earthquakes to the smaller motions which help characterize the regional earthquake hazard.
2. Continuously record ground motions, functioning through power and communications failures or other disruptions during damaging earthquake sequences.

B. Interagency cooperation. Cooperate with other agencies working to mitigate the earthquake hazard in southern California in the recording, analysis, and distribution of information, especially the Division of Mines and Geology, the Office of Emergency Services, the Federal Emergency Management Agency, the Southern California Earthquake Center, and the Council of the National Seismic System. Ensure that software systems created under this project will be available to other regional networks working toward similar goals.

C. Database of earthquake information.

1. Create a catalog of parameters for all earthquakes of magnitude 1.8 and greater onshore within the SCSN reporting area and magnitude 2.5 and greater offshore, which will be used to evaluate the rate of seismicity and provide insight into the structure of the Earth.
2. Record high fidelity data on-scale with broad-band sensors with sufficient density to produce maps of site response characteristics and to elucidate the earthquake source.
3. Record on-scale, high-fidelity data on broad-band sensors and accelerometers with sufficient density to characterize ground motions for all large earthquakes and document the level of shaking buildings endured, providing knowledge society needs to build a resilient infrastructure.
4. Record continuous ground motions from all broad-band sensors.
5. Make these data easily accessible to researchers and practitioners.

D. Rapid distribution of information. Distribute earthquake information rapidly after a damaging event to save lives and property by facilitating decision-making for mitigating actions such as search and rescue, fire prevention, and deployment of engineers and inspectors for building inspection.

1. Determine and broadcast accurate estimates of earthquake parameters, such as magnitude and location, within one minute of the termination of an earthquake rupture.
2. Distribute preliminary estimates of the ground shaking (ShakeMap) within three minutes of onset for moderate and large events. These estimates will be updated as further information becomes available.
3. Provide data acquisition and processing capability to other agencies that record ground-motion instruments installed in critical structures and transmit this information for emergency response.

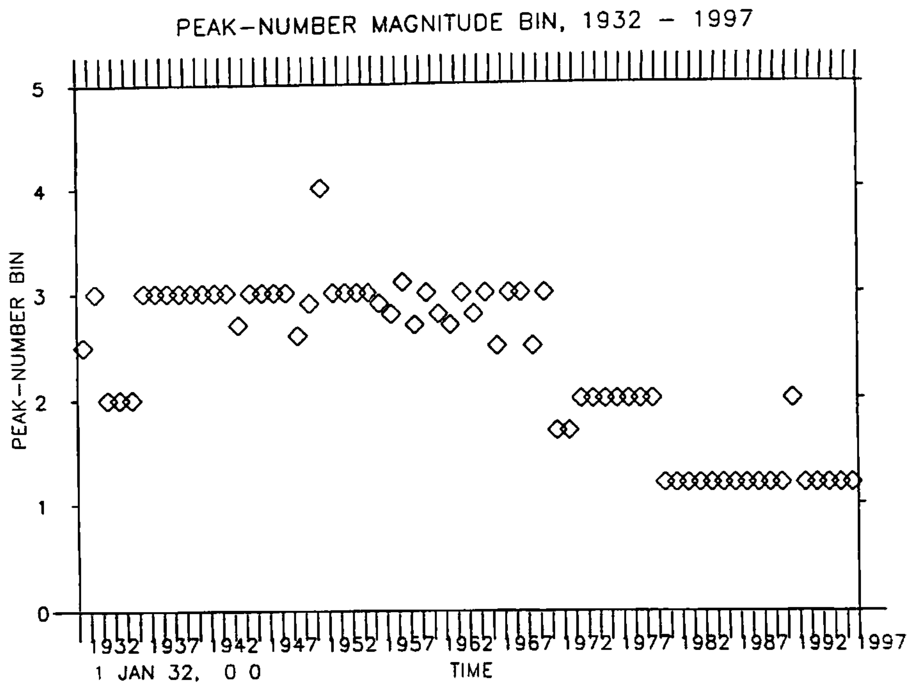
E. Pilot early-warning system. Develop a pilot early-warning system that would allow an alert that an earthquake has begun before damaging shaking arrives at distant sites. Conduct social science research on methods for implementing such a system when funds for future SCSN/TriNet enhancements, including sufficient stations, become available.

1. The system will allow us to determine that an earthquake is in progress and estimate resulting ground motions within 5–10 seconds of the arrival of the *P* wave at stations near the epicenter.
2. Processing systems will be expandable to accommodate the number of stations necessary for implementation of early warning. They will also be resilient to the strong shaking and high data-flow rates generated in a major earthquake sequence.

CATALOG COMPLETENESS IN SPACE AND TIME

The SCSN has been operational for more than 66 years with varying but generally increasing station density. The minimum magnitude earthquake that can be reliably detected and located depends on station density, which has varied geographically and temporally. In this study, we divide the catalog entries into 0.1-wide magnitude bins and note the magnitude value Mf which occurs most frequently in various subsets of the earthquake catalog. Since smaller earthquakes dominate the catalog, Mf serves as a quick and dirty indicator of the detection threshold. Theoretically the actual magnitude threshold at which the SCSN detection is complete is 0.1 or 0.2 units higher than Mf. We determined the *b*-value for earthquakes of magnitude Mf and larger, $Mf + 0.1$ and larger, and $Mf + 0.2$ and larger. For samples containing more than about 100 events, the three *b*-value determinations are essentially the same, which suggests that Mf is a reasonable estimate of the completeness level. In the future, we will implement a more sophisticated method of estimating completeness. This method, however, is fast and easy, and it yields some interesting results.

We computed Mf for one-degree boxes in the coverage area for ten-year time periods starting in 1932. We required at least 50 earthquakes in each box. During the early years, from 1932 to 1971, the threshold in most of the central part of the Network was about M3. By the 1980's, with a much higher station density, a large part of the Network was routinely detecting magnitude M1.2's. Most magnitudes for earthquakes between 1932 and 1944 were only computed to the nearest half unit, *i.e.*, either 3.0, 3.5, 4.0, etc. Thus, we



▲ **Figure 1.** The most frequent magnitude, *Mf*, for the central area of the SCSN, as a function of time. This reflects the overall sensitivity level of the SCSN since its inception in 1932.

can only estimate completeness to the nearest half-magnitude during that time.

In a few instances, individual earthquake sequences influenced the completeness level. One example is the 1933 Long Beach sequence. Because of the proximity to stations PAS (Pasadena) and MWC (Mt. Wilson), more small aftershocks were located than would otherwise have been the case, which pushed the *Mf* value in that bin down to 2.0. During the following decade, when presumably the earthquakes were more evenly distributed over the geographic region, *Mf* was 2.5. Another example appears in the 1982 to 1991 time period, when the offshore Oceanside sequence was divided between the 33°N, 117°W box and the 33°N, 118°W box. No stations were close to this epicentral region, so few quakes below M2.0 were detected, and the *Mf* values were higher than they would have been if only L.A. Basin quakes had contributed to the determination.

To see exactly when changes in major Network detection capabilities occurred, we look at the *Mf* values for the "core area" of the Network, from latitude 33° to 36° N and longitude 116° to 119° W, as a function of time (Figure 1). This core region of the SCSN detected M3.0 and larger quakes from 1932 to about 1956 and increased slightly from 1957 through 1971 when, following the San Fernando earthquake, a significant number of additional stations were added. The Network was further improved by changes in the data processing software and the further addition of stations in the early 1980's. This pattern was occasionally disrupted by several large aftershock sequences which either flooded the catalog with small quakes, as in the 1933 Long Beach or 1971 San Fernando sequences, or overloaded the data processing to the point where normally detectable quakes passed through the system unexamined. The latter case can be seen in 1952 for the Kern County sequence and 1992 for the Landers sequence.

Finally, in Figure 2 we compute the *Mf* values for the newly recomputed 1955 through 1959 catalog (next section). The figures reflect the slightly smaller magnitudes that we found in the recomputation. Also, because of the shorter time period, more of the boxes had an insufficient number of earthquakes.

"MOLDY OLDIES": IMPROVEMENT IN EPICENTERS AND MAGNITUDES

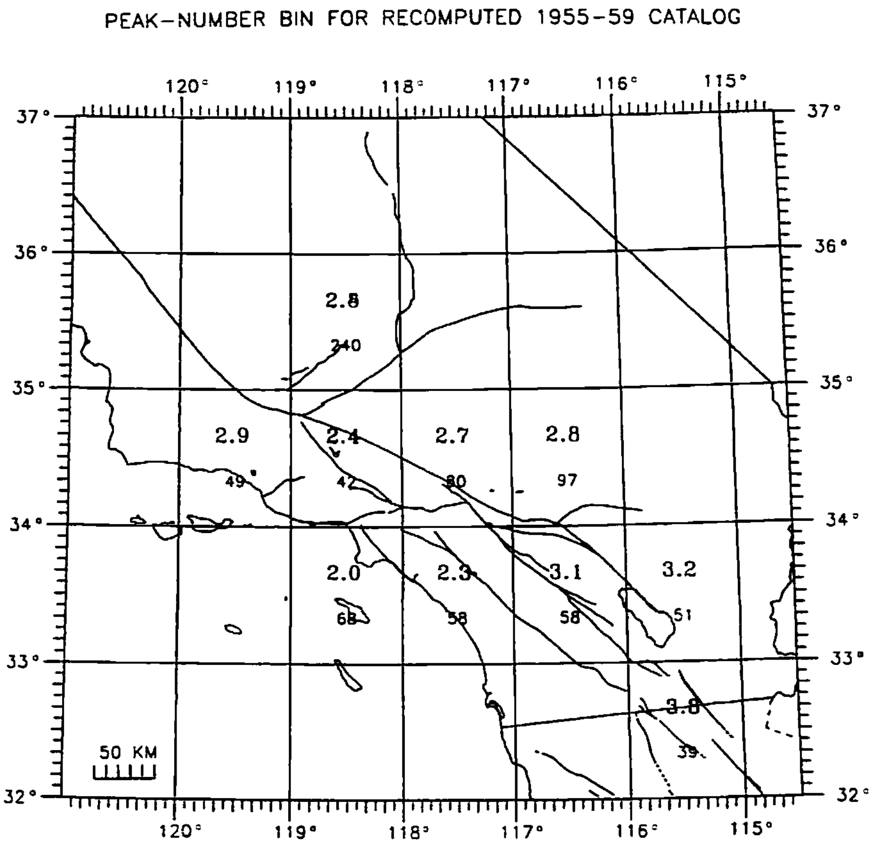
The SCSN has undertaken a project to improve the quality of epicenters and magnitudes in the older parts of its catalog. Historically, the analysis methods used have divided the catalog into three sections:

1975 to the present: These data are, for the most part, thoroughly computerized, although there are still some backlogs and some problems.

1960 through 1974: The picks were made by hand but have been entered into computer-readable form.

1932 through 1959: These data were picked by hand and, for the most part, graphically located.

The data in the time period 1932–1959 are the subject of this discussion.



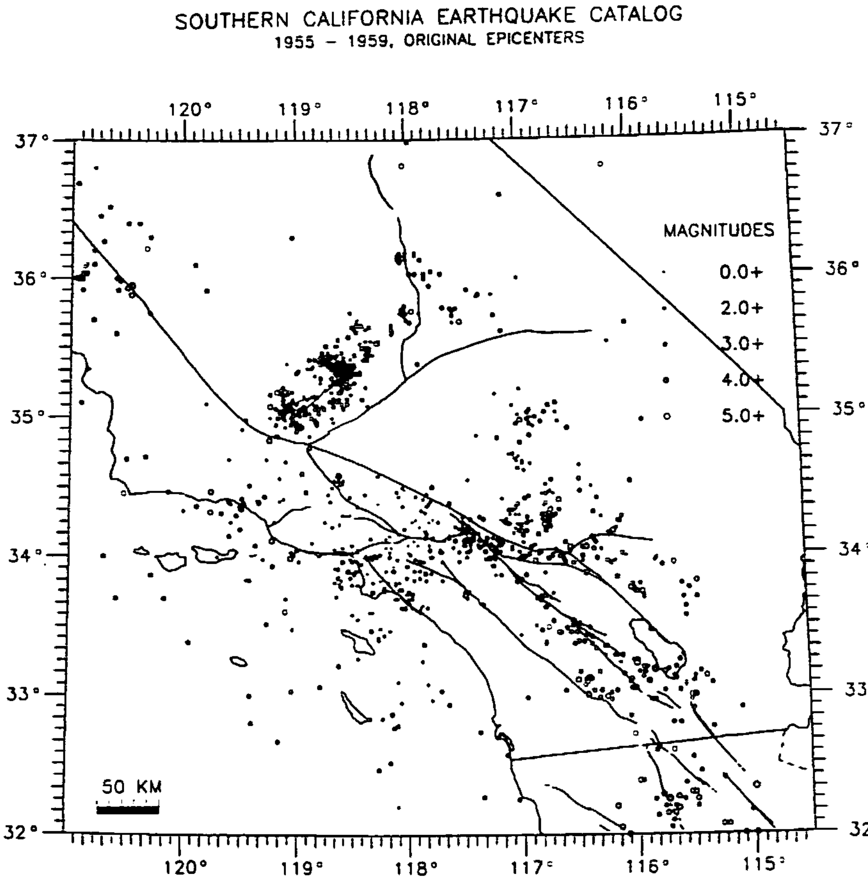
▲ **Figure 2.** The most frequent magnitude, *Mf*, by geographic area, for the recomputed 1955 through 1959 SCSN earthquake catalog.

Just prior to the 1992 Landers earthquake, the Caltech Seismological Laboratory contracted to a data entry service the task of computerizing the old local earthquake "phase cards" containing information for events recorded from 1932 through 1959. The phase card archive consists of 33 file cabinets full of 5" by 7" index cards, upon which are penciled the raw arrival times, clock corrections, corrected arrival times, and amplitudes that were read off the photographic or visible drum records with the assistance of a ruler and magnifying glass. Included with the index cards are vellum pages containing the compass arcs that were used to locate graphically the local earthquakes. The ASCII files produced by the contractor have been available through the SCEC_DC since 1992. However, they are of limited value to researchers because of various problems with the transcription of the cards (discussed below) and because there had been no quality control over the individual picks other than notations made on the phase cards which could not be translated into the ASCII format.

During the past year we have been reading these events into the CUSP system and attempting to find the best location and magnitude for each event on an interactive basis. A small percentage of the events required no changes, but most have had some problems. The less important problems include illegibility of the original handwriting, various obscure notations, and decimal points that had rubbed off over the years. The most common significant error was an offset of one minute in the origin time listed relative to the phases. Because the location and origin time were determined manually and graphically, this is an understandable mistake. Where our computed origin time differed from the one in the Hileman *et al.* (1973) catalog, we used our computed origin time since we assumed it was more reliable. We did not reread any seismograms. Occasionally phases were also off by one minute. In that case we selected the best phases to be used in the new location determination.

The second most common error was the misreading of *Pg* as the initial *P* time at the more distant stations. The bulk of the earthquakes were in the M_L 3 range, and we found that, for those events, the initial arrival time could be trusted to approximately 100 to 150 km distance from the epicenter. Beyond that, the *P* and *S* observed arrivals were increasingly late with respect to the predicted arrivals. Using a weighting scheme from 1 to 4, 1 carrying the most weight and 4 carrying the least, a weight of 4 was applied to all arrivals that followed this late-arrival pattern, meaning the phase information was archived but not used in the hypocentral solution.

There is probably room for improvement in the station clock correction history. We looked at the clock correction history, as indicated on a separate set of phase cards, for several stations. We were dismayed to see the clocks had often drifted by more than one minute during a one-day or less period. However, the manual interpolations performed

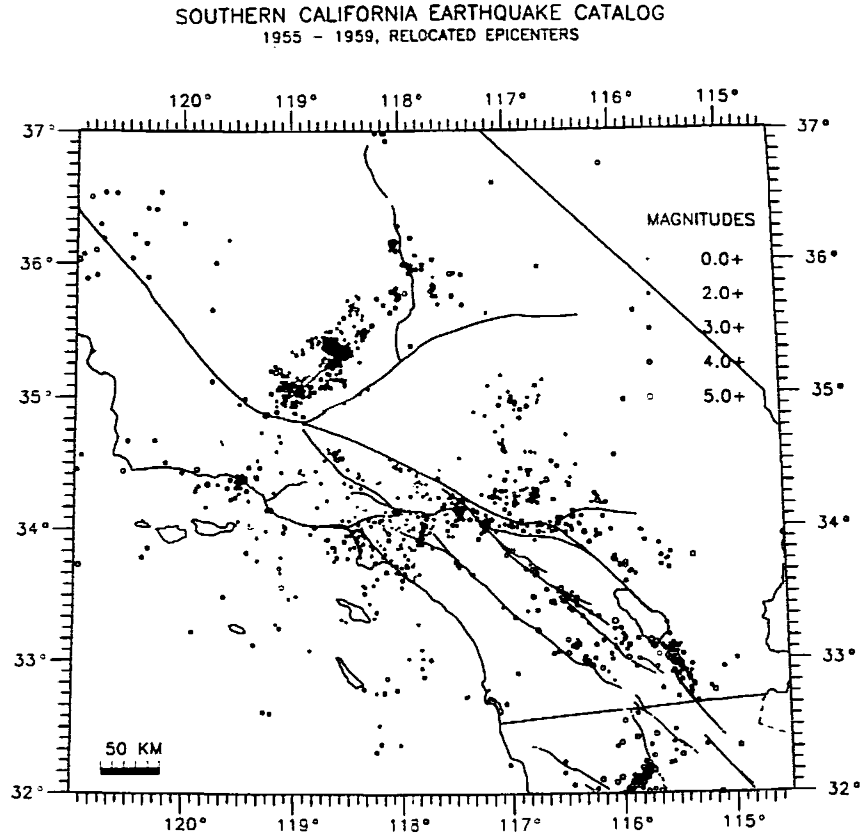


▲ **Figure 3a.** Old graphically derived locations of SCSN earthquake catalog events 1932–1959.

under these conditions are amazingly accurate. In addition, there appear to have been shorter-term random fluctuations, perhaps due to temperature, that were real rather than a result of a reading error. We confirmed this by treating these variations as random noise and interpolating the time correction at the time of the earthquake based on a polynomial curve. The RMS was no better, and in most cases was worse, for the origin time than for the original hand interpolations. We did not read the time corrections ourselves. We did, however, archive the data in such a way that each station has an individual time base which will allow changes at a later date. Most events had an origin time RMS of 0.5 sec. We assigned a weight of 4 to all readings that were off by more than two seconds. Because of the sparseness of seismic stations, the closest station to most earthquakes was greater than 25 km, rendering it impossible to determine the focal depth from most of the arrival time data. Therefore, the depth was fixed at a value of 6 km for most events.

The epicenters are shown in the accompanying maps. Figure 3a shows the old graphical locations, and Figure 3b shows the new ones. Two trends are apparent. First, the seismicity appears to be higher in some areas (for example, Imperial Valley) in the relocated catalog. This is because the original catalog assumed a fixed location for many defined events, so they all plot on top of each other on the map. Also, some areas (the San Bernardino area, for example) show a fairly clear increase in the "structure" of the seismicity distribution (such as discrete lineations, etc.), which suggests that the new epicenters are probably more accurate. Improvement was expected but was not necessarily a foregone conclusion. Although least-squares fitting makes better use of the complete set of arrival times for an event, graphical locations can be made on the basis of S minus P times, even if the clock corrections are grossly incorrect. Outside of the SCSN, in northern Mexico and the Parkfield/Coalinga area, for example, there is more scatter in the geographic distribution than there was before. This may be due to the use of additional information sources, such as locations from the University of California Berkeley network, to supplement the graphical methods.

A small but important systematic change emerged in the magnitude computations. Since 1978, we have been computing an M_L estimate individually for each available Wood-Anderson or well calibrated synthetic Wood-Anderson amplitude reading and then using the median of the values. The median was chosen because it is less sensitive to outliers than the mean. The difference can be significant in the pre-1960 data where there may only be a few readings. Furthermore, we do not know the magnitude determination procedure that was used prior to computerization of the SCSN in 1978. There does not appear to have been a systematic procedure for assigning magnitudes. During that time period a magnitude correction was also computed for each of the ver-



▲ **Figure 3b.** New locations of SCSN earthquake catalog events 1932–1959 after interactive processing.

tical Benioff instruments under the erroneous but convenient assumption that it had a Wood-Anderson-like response. These readings, labeled *MH* on the phase cards for "helicorder magnitude", were used when there were fewer than three real Wood-Anderson readings. During the late 1950's, when few quakes smaller than M3 were even read, this amounts to only a handful of events. Even so, the final magnitudes do not always bear a relationship to the individually recorded M_L's or *MH*'s.

A previous study (Hutton and Jones, 1993) found a small systematic difference between M_L's calculated with the current technique and the earlier estimates for earthquakes larger than M4.8. The computed magnitudes are systematically 0.07 smaller than the earlier assigned ones. This small difference is extremely important for seismicity rate statistics. Because M_L 4.8+ quakes provide a sparse sample for rate statistics, we were very interested to see whether the events smaller than M4.8 showed the same difference. In fact, they do. For 1,323 events from 1955–1959, the newly computed magnitudes are 0.072 smaller than the ones in the Hileman *et al.* (1973) catalog. If we were to assume a *b*-value of 1.0, the catalogued seismicity rate for 1955–1959 would be 18% higher than the rate using modern methods.

The reassessment of catalogued earthquakes from 1932–1959 will continue in reverse chronological order, and we will replace segments of the online searchable SCSN catalog provided by the SCEC_DC as each five-year subset is completed. Following that, we will address the quality control issue for the period 1960 through 1973. There were more stations in the SCSN during that time period, so the existing hypocenters are more reliable. However, the magnitudes have never been checked.

THE USGS PASADENA WEB

The USGS Pasadena office has a new web server. It is a Sun UltraSparc-II with a 296 MHz CPU and 256 MB of memory, running Solaris 2.6 and a Netscape server. There are three 4.2 GB disks attached to it. One is mounted internally and contains the system software. A second SCSI controller is attached to an external storage unit with the other two disks in it. The disks are set up to be identical, which provides some redundancy in case of failure.

The machine is set up with a total of four network addresses. The first is for the machine itself. The second is identified with the scweb-south web server and is used for serving the USGS Pasadena home page. The third is set up to be ncweb-south and serves a mirror of the USGS Menlo Park web pages. The fourth address is not currently active but can be turned on to serve as a mirror of the main USGS Earthquake Hazard pages. Updates of the mirror copies are performed automatically from Menlo Park.

There are several recent additions to the Web site:

Surfing the Web for Strong Ground Motion Data: a compilation of ground motion data sources
http://www-socal.wr.usgs.gov/smdata.html

List of Historical California Earthquakes 1732–present
http://www-socal.wr.usgs.gov/eq_hist.html

SeismoLinks: a comprehensive compilation of links to earthquake, volcano, and geological information
http://www-socal.wr.usgs.gov/seismolinks.html

GeoFact of the Week: a new "geofactoid" each week
http://www-socal.wr.usgs.gov/lisa/geofact.html

In addition, the "Current CA/NV Earthquakes" page and the "Shake Maps" page have been upgraded also.
http://www.scec.scecdc.org/recenteqs
http://www-socal.wr.usgs.gov/pga.html

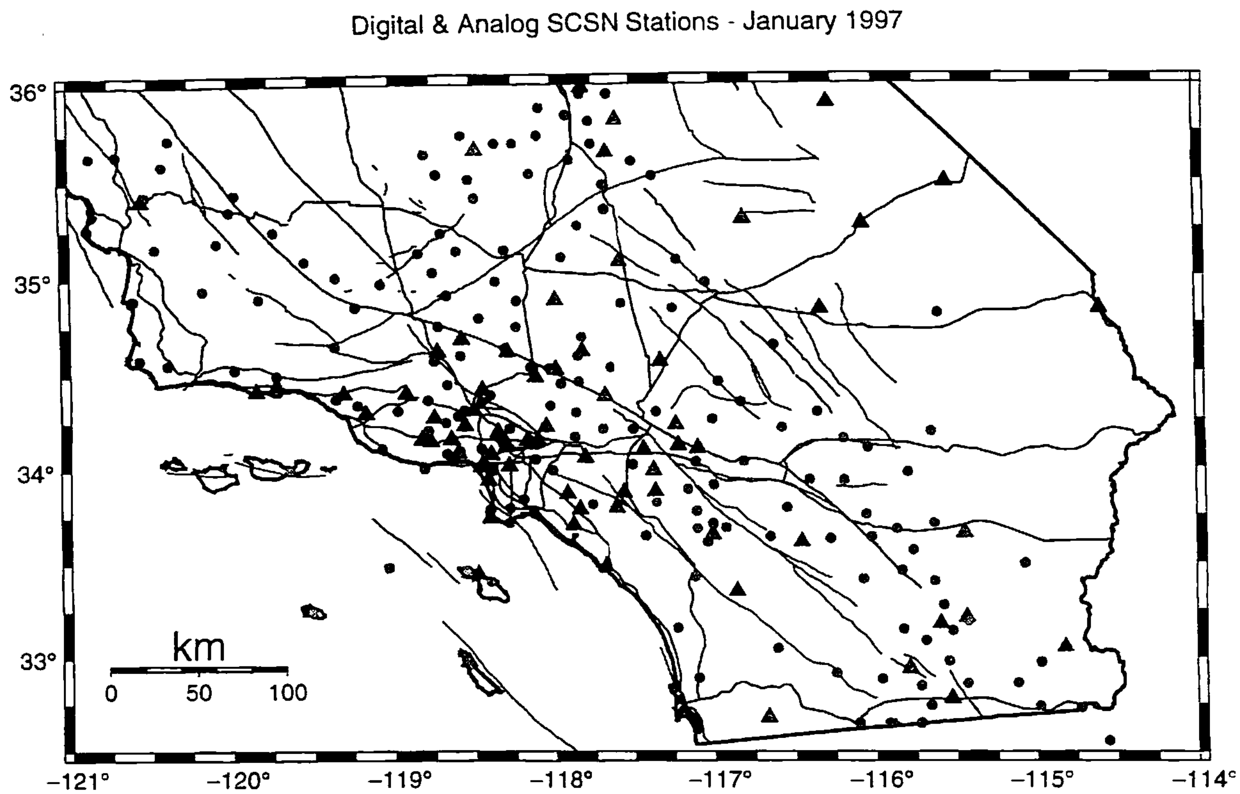
NEW STATIONS

Almost all of the new seismic stations added to the Network in 1997 were digital stations. All new digital and analog stations added through December 31, 1997 are included in Table 1. A list of all currently operating stations may be found at http://scecdc.scec.org/statlist.web. Figure 4 shows the locations of all the current SCSN analog and digital stations. The stations with K2 instruments were installed by the USGS as a part of the National Strong Motion Program (NSMP).

TABLE 1
New Stations Added to SCSN in 1997

Code	Site Name	Lat. (North)	Long. (East)	Elev (m)	Date Installed	Instr.
BBA	Burbank Airport	34.19551°	−118.35340°	unknown	10/15/97	K2
BBB	Bombay Beach	33.21178°	−115.43987°	unknown	11/24/97	K2
BC3	Big Chuckwalla	33.65480°	−115.45310°	1080	09/20/97	SQUASH
BTP	Burnt Peak	34.68170°	−118.57380°	1579	12/01/97	SQUASH
BVH	Beverly Hills	34.07618°	−118.39590°	69	04/07/97	K2
CAB	Calabasas	34.15573°	−118.64093°	289	04/07/97	K2
CIU	Catalina Island	33.44577°	−118.48300°	233	07/02/97	SQUASH
CPP	Cal Poly Pomona	34.06020°	−117.80900°	235	02/07/97	SQUASH
EDW	Edwards AFB	34.88303°	−117.99106°	762	02/06/97	SQUASH
ELC	El Centro	32.78140°	−115.53560°	unknown	11/21/97	K2
FLL	Fillmore	34.39727°	−118.91807°	133	04/07/97	K2
FPC	Federal Prison Camp	35.08200°	−117.58267°	883	02/19/97	SQUASH
GRF	Griffith Park Observ	34.11920°	−118.30040°	unknown	10/02/97	K2
HEC	Hector	34.82940°	−116.33500°	959	08/01/97	SQUASH
*HOL	Holcomb Ridge	34.45825°	−117.84505°	1190	05/15/97	L4C
JFP	Jensen Filtration Plant	34.30870°	−118.50260°	260	11/24/97	K2
LAX	Los Angeles Airport	33.94382°	−118.41390°	unknown	12/02/97	K2
LTR	Littlerock	34.52110°	−117.99030°	unknown	10/02/97	K2
OKV	Oakview	34.39681°	−119.29923°	156	03/27/97	K2
PHL	Park Hill	35.40770°	−120.54562°	360	07/23/97	TERRA
PLM	Palomar	33.35370°	−116.86270°	1660	04/08/97	SQUASH
SCI	San Clemente Island	32.97990°	−118.54704°	246	09/30/97	SQUASH
SMS	Santa Monica Fire Stn	34.01467°	−118.45617°	53	06/18/97	SQUASH
SSW	Salton Sea Wildlife Ref	33.17660°	−115.60240°	unknown	10/02/97	K2
SWS	Sam W. Stewart	32.94080°	−115.79580°	unknown	09/20/97	SQUASH
TAB	Table Mountain	34.38245°	−117.68191°	2250	02/06/97	SQUASH
TCF	Topanga Canyon	34.08377°	−118.59900°	233	11/24/97	K2
TOV	Thousand Oaks/Ventura	34.15600°	−118.82021°	332	10/03/97	SQUASH
USB	UC Santa Barbara	34.41300°	−119.84270°	12	08/21/97	SQUASH
VCS	Vincent Substation	34.48399°	−118.11762°	962	09/09/97	SQUASH

* next to a station code indicates an analog site.



▲ **Figure 4.** Southern California Seismographic Network, January 1997. Filled triangles represent digital stations; filled circles are analog stations.

DISCONTINUED STATIONS

Thirteen stations were discontinued in 1997. The removal dates are shown in Table 2. A few were moved (and renamed) to nearby locations for a variety of reasons, such as vandalism problems, telemetry problems, etc., and many were removed as they were replaced with digital instruments at nearby sites.

TABLE 2
Discontinued Stations in the SCSN in 1997

Code	Station Name	Date Terminated
BRG	Borrego Mountain	04/30/97
COY	Coyote Mountain	04/30/97
FIL	Fillmore	04/30/97
IND	Indio	04/30/97
LLN	Llano	05/12/97
LOK	Lockwood Valley	05/05/97
MNT	Mint Canyon	05/08/97
PLM	Palomar	04/30/97
PVR	Palos Verdes	04/22/97
SNS	San Onofre	02/24/97
WWR	Whitewater	04/30/97
YAQ	Yaqui Meadows	11/07/97
CALB	Calabasas	07/25/97

PROCESSING STATUS OF NETWORK DATA

The processing status for each month of the catalog since the advent of digital recording is described in Table 3. Events for months marked P (preliminary) have been timed but have not yet run the gauntlet of quality checking, addition of helicorder amplitudes, and re-archiving necessary to become final (F with shading). For months marked PNK (pinked), large events (~M3.0) have been only crudely timed on a few stations, while 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 research requiring the best magnitudes or completeness estimates for large events. The last three quarters of 1981 and several months in 1993–94, 1996, and 1998 (marked P) are nearly finalized, needing only magnitude calibrations. We are presently timing and finalizing 1983 data.

SUMMARY OF SEISMICITY

A total of 13,429 earthquakes and 1,540 blasts were catalogued for 1997 (Figure 5). Of the catalogued events, 169 were greater than or equal to M_L3.0 (Appendix A). The largest earthquake within the SCSN network in 1997 had a magnitude of 5.3 and was called the "Calico earthquake." Focal mechanisms for 14 selected events ($M_L \geq 4.0$) are shown in Figure 6.

TABLE 3
Processing Status of Network Data

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	PREDIGITAL RECORDING: COMPLETE FOR M≥3.0											
1932–1974												
1975	F	F	F	F	F	F	F	F	F	F	F	F
1976	F	F	F	F	F	F	F	F	F	F	F	F
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	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK
1981	PNK	PNK	P	P	P	P	F	F	F	F	F	F
1982	F	F	F	F	F	F	F	F	F	F	F	F
1983	P	PNK	PNK	PNK	PNK	PNK	PNK	F	F	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	F	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	F	F	F	F	F	F	F	F	F
1990	F	F	F	F	F	F	F	F	F	F	F	F
1991	F	F	F	F	F	F	F	F	F	F	F	F
1992	F	F	F	P	P	P	P	P	P	P	P	P
1993	F	F	F	F	F	F	P	P	P	P	P	P
1994	P	P	P	F	F	F	F	F	F	F	F	F
1995	F	F	F	F	F	F	F	F	F	F	F	F
1996	F	F	F	F	F	F	P	P	P	P	P	P
1997	F	F	F	F	F	F	F	F	F	F	F	F
1998	P	P										

F: Final; P: Preliminary; PNK: Pinked

For the following discussion southern California has been divided into eleven subregions (Figure 7). These regions are arbitrary but useful for discussing characteristics of seismicity in a manageable context. Figure 8 summarizes the activity of each subregion over the past ten years. A separate discussion section follows for those regions with notable activity. Earthquakes of M3.5 or greater, or those of any size that were felt, are discussed. The dates mentioned in the text are based on Pacific time; however, those in Appendix A are based on GMT, thus the discrepancy in a few dates.

Imperial Valley—Region 1.

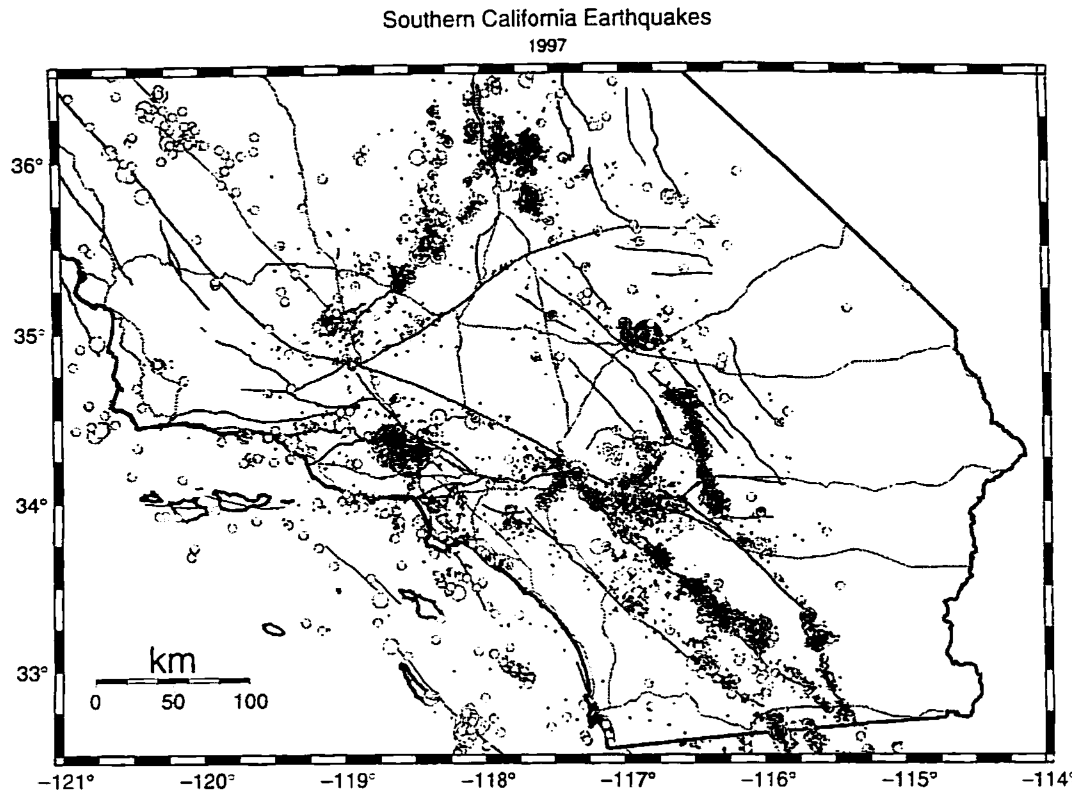
This region experienced the usual swarms and small events both north and south of the California/Mexico border in 1997. In mid-January there was a small swarm at the north end of the Brawley Seismic Zone, which connects the northern end of the Imperial Fault with the southern end of the San Andreas Fault. Another significant swarm occurred in the same area throughout December, which included an M4.1 event on December 31 (Figure 6, #14). This earthquake had a right-lateral strike-slip mechanism, typical of events in the area.

Just south of the border, 13 km (8 mi) south-southeast of Ocotillo, there were an M3.5 earthquake that was felt in El Centro on February 1 and another M3.5 in the same location on February 11. A small swarm also occurred south of the border in August and September.

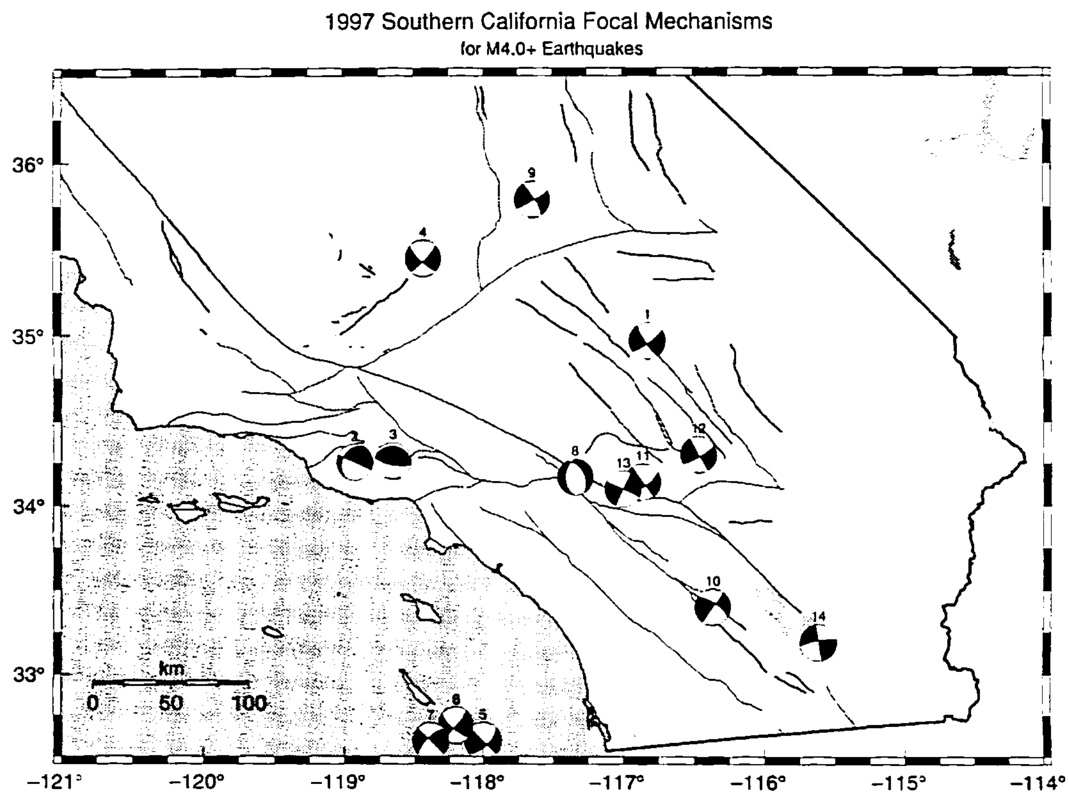
Northeast of Calexico, near the border, there were three M3.5's on June 23, July 3, and July 5. Then 47 km (29 mi) south-southeast of Calexico, in Baja, there was an M3.8 event in November.

South San Jacinto—Region 2.

An M3.5 earthquake was felt in the Salton City area near a secondary strand of the San Jacinto Fault on January 13. Slightly northwest of that near Anza an M3.8, preceded by an M1.5 foreshock 22 seconds earlier, occurred on yet another secondary fault near the San Jacinto Fault on Febru-

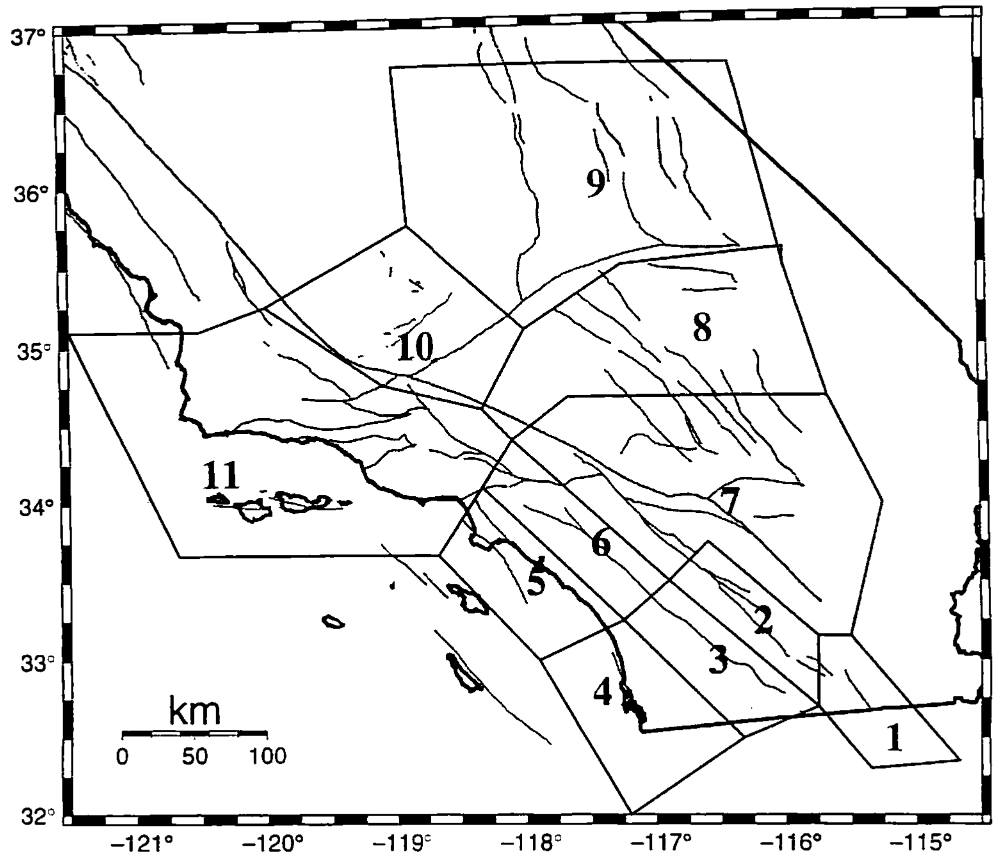


▲ **Figure 5.** Map of all located earthquakes in southern California for the period of January–December 1997.



▲ **Figure 6.** Lower hemisphere focal mechanisms for selected events for the period January–December 1997. Event numbers correspond to numbers in F column of Appendix A.

Seismicity Summary Regions



▲ **Figure 7.** Boundaries of subregions used in summary of seismicity. 1 = Imperial Valley, 2 = South San Jacinto, 3 = South Elsinore, 4 = San Diego, 5 = Los Angeles, 6 = North Elsinore, 7 = San Bernardino/South Mojave, 8 = North Mojave, 9 = South Sierra Nevada, 10 = Kern County, 11 = Santa Barbara.

ary 6. These were normal-faulting focal mechanisms on a north-striking fault.

The largest event in this region was an M4.9 earthquake 16 km (10 mi) north of Borrego Springs on July 25 that was widely felt. This strike-slip event was located along a branch of the San Jacinto Fault near Clark (Dry) Lake (Figure 6, #10).

South Elsinore—Region 3.

Both noteworthy events in this region were located near Mount Palomar. The first, on January 13, was an M3.6 just northwest of Mount Palomar near the Agua Caliente Fault (an offshoot of the Elsinore Fault). The second, on July 28, was an M3.4 event that was felt slightly in the Escondido area. This oblique thrust event was also on a secondary fault off the Elsinore Fault.

San Diego—Region 4.

The first event of the year felt in San Diego was not located in this region. It was an M3.2 event on May 16 in northern Mexico. However, almost all the significant activity in this region was offshore near the southeast tip of San Clemente Island. The bulk of the action occurred on June 19 and 20 with an M4.7 and M4.2 the first day, followed by an M4.6 on the second (Figure 6, #5, #6, and #7). In addition, there were several M3.0+ and many M2.0+ aftershocks. The largest two of these were felt in San Diego and Orange Counties.

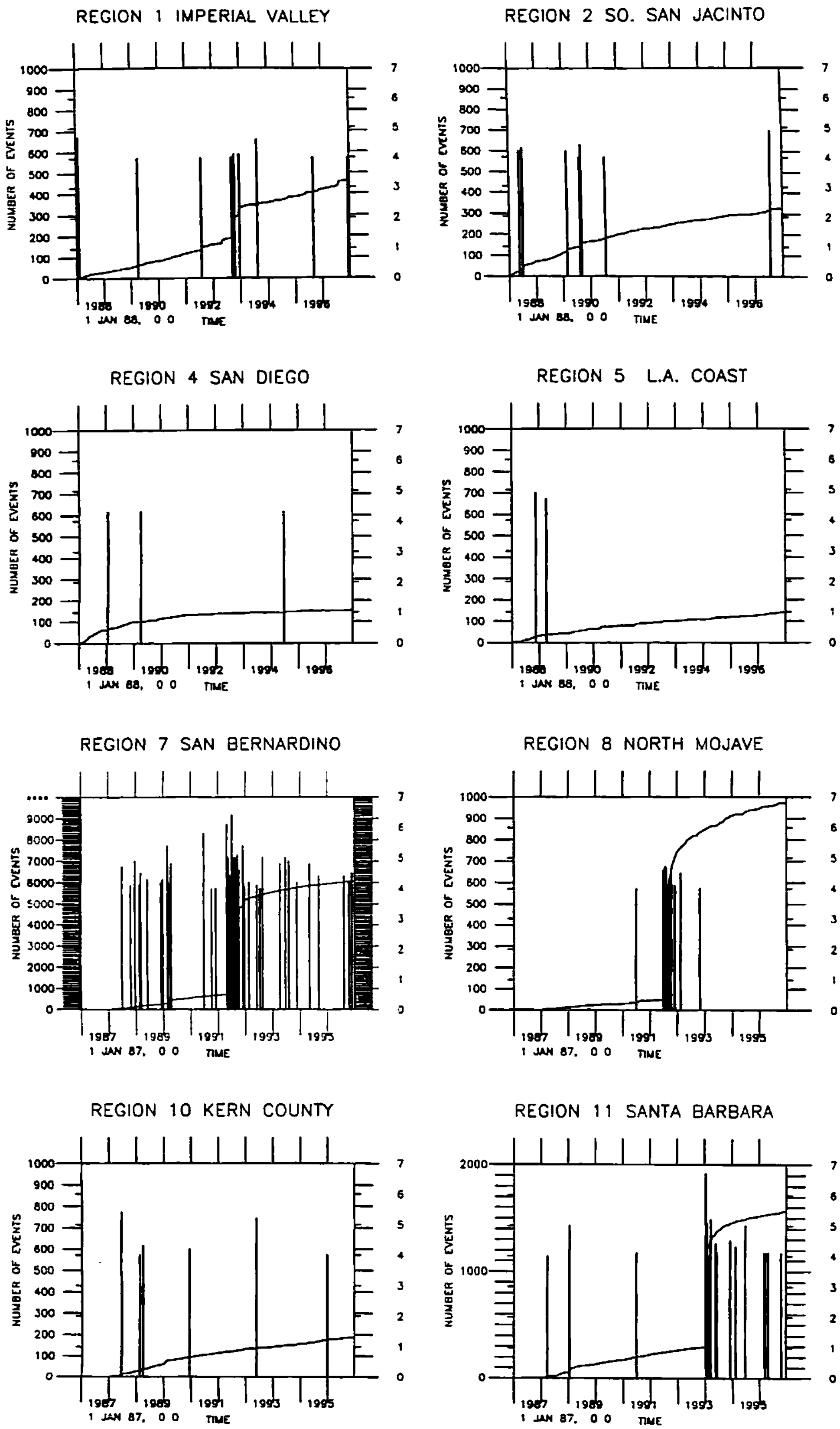
On August 12, this area had an M3.7, followed by an M3.5 on November 25. All these events were probably located on the San Clemente Fault.

Los Angeles—Region 5.

There was the usual smattering of small but felt events in the Los Angeles metropolitan area in 1997. An M3.3 with two small aftershocks was felt near Inglewood on April 4. It was located near the Newport-Inglewood Fault Zone, with a focal mechanism consistent with events on that fault. The following month on May 15, an M3.1 offshore of Manhattan Beach was felt in the South Bay area. The residents of Catalina Island felt an M3.1 on September 2 located 16 km (10 mi) northeast of Avalon, while a small M2.9 that was 18 km (11 mi) offshore of Newport Beach near the Palos Verdes Fault was felt in the Newport Beach area.

North Elsinore—Region 6.

The only significant events in this region were an M3.5 on January 31 near Yorba Linda that was felt widely in Orange County and the Inland Empire, and an M3.0 on March 7 that was felt in the Ontario area.



▲ **Figure 8.** Cumulative number of events ($M_L \geq 2.5$) in all subregions over the ten year period ending December 1997. The boundaries of the subregions 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.

San Bernardino/South Mojave—Region 7.

This area had the typical level of moderate activity in addition to continuing aftershocks from the June 28, 1992 Landers/Big Bear earthquake sequence. Starting in the far southern part of the region, there were an M3.6 and an M3.2 on December 26 and 27, respectively, near Bombay Beach in Imperial Valley just 6 km (4 mi) south of the south end of the San Andreas Fault. On February 27 an M3.8 shook the Little San Bernardino Mountains northeast of the Coachella Valley. It was followed by two aftershocks, an M3.5 and M3.1. All were felt in the area. They were on a secondary splay of the San Andreas (8 km to the east) with compatible strike-slip mechanisms.

The Fontana area, west of San Bernardino, felt an M3.9 earthquake on October 14 and an M3.6 on November 4. Both had strike-slip mechanisms. An M3.2 strike-slip earthquake occurred under Loma Linda just south of San Bernardino on June 10 and was felt in San Bernardino and Riverside. The area just northwest of San Bernardino experienced a flurry of activity in June, July, and August, beginning with an M4.2 event on June 28 with a normal focal mechanism (Figure 6, #8). An M3.5 followed in the same location on July 12, an M3.7 on July 26, and then two M3.1 events on August 13 and September 2.

On December 5 the Yucaipa area experienced an M4.1 earthquake that was felt in the Inland Empire (Figure 6, #13). This strike-slip event was probably on the north branch of the San Andreas and was considered an aftershock of the Landers/Big Bear sequence, since this area had an increase in activity during the mainshock sequence.

North Mojave—Region 8.

The largest event in this region, and in southern California in 1997, was an M5.3 aftershock of the June 28, 1992 Landers earthquake; it occurred on March 18 near Barstow at the south end of the Barstow cluster (Figure 6, #1). It was widely felt in the epicentral area and as far away as Orange County. It was given the name "Calico earthquake" since it was located at 6 km (4 mi) depth on the north end of the Calico Fault. It had a right-lateral strike-slip focal mechanism on a fault striking N30°W, consistent with the orientation of the Calico Fault. The maximum acceleration recorded in the earthquake was 8.2% g at Flash Peak (FLS), 19 km (12 mi) west of the mainshock. Within four hours, there were eleven aftershocks ranging in size from M1.8 to M3.7. This was the twenty-third M5.0+ earthquake in the Joshua Tree/Landers/Big Bear sequence. The one previous was on June 16, 1994.

An M4.1 occurred in the Big Bear aftershock zone on September 19 which had a few small aftershocks of its own (Figure 6, #11). It was followed a little more than a week later by an M4.4 in the Landers aftershock zone that was widely felt in Yucca Valley and Palm Springs (Figure 6, #12). An M3.6 aftershock happened on April 21. A resurgence of activity in this area occurred on May 22 and 23 with an M3.6 the first day and an M3.5 and an M3.3 the second. Later in the year on November 5 an M3.8 shook the area yet again.

South Sierra Nevada—Region 9.

Three distinct areas saw significant activity in this region in 1997. Seismicity in the Coso geothermal area typically occurs in swarms, and 1997 was no exception. The M_w 5.3 Coso earthquake on November 27 produced several notable aftershocks that were among the swarms. On January 4 an M3.8 occurred, and on January 11 an M3.6 occurred as part of a swarm that continued throughout January. A resurgence of activity beginning in mid-February included an M3.8 on February 14 and an M3.7 on February 15. It continued into March with an M3.6 on March 8, after which the area quieted down for the remainder of the year.

The Lake Isabella area was another site of earthquake activity. On May 6 an M4.5 strike-slip event located in the Sierra Nevada south of Lake Isabella was felt in Tehachapi and Ridgecrest (Figure 6, #4). This is in the Southern Sierra Seismic Lineation, a common source of microseismicity. Subsequent activity included an M3.5 on August 31, an M3.5 on October 27, and an M3.6 on November 13.

Slightly further south in the Ridgecrest area there were a few notable events midyear. An M3.9 occurred on May 23 in the same area of the 1995 and 1996 Ridgecrest swarms, which included two M5.0+ events. On July 3 an M4.3 earthquake shook the same area (Figure 6, #9).

Kern County—Region 10.

No significant seismic activity was recorded in this region in 1997.

Santa Barbara—Region 11.

There was some interesting activity in this region in 1997. On May 18 an M3.1 occurred near Santa Maria, north of Santa Barbara, that was felt in the area. Then in late May and early June there was a swarm, which is not typical for this area. It was located in the Carrizo Plain near the San Andreas Fault and included six earthquakes; the largest was an M2.5. Just offshore south of Santa Barbara in the Santa Barbara Channel an M3.6 was felt on February 21.

Aftershocks of the January 17, 1994 Northridge earthquake continued throughout the year. An M5.1 aftershock occurred on April 26 just 10 km (6 mi) north-northeast of Simi Valley (Figure 6, #2), and an M4.9 followed the next day 8 km (5 mi) west-southwest of Valencia (Figure 6, #3). Both events shook people awake early on Saturday and Sunday mornings. These two events were not on the Northridge mainshock plane but rather were on a steeply dipping east-west-striking structure. A week later on May 3 an M3.5 was also felt on the north edge of the aftershock zone.

On September 25 an M3.4 occurred in the San Gabriel Mountains north of Lake View Terrace that was felt in northeast San Fernando Valley. This event was outside the Northridge aftershock zone.

FOR FURTHER INFORMATION

To order back issues of the Southern California Seismic Network Bulletins for 1985–1996, contact the USGS at Books and Open-File Reports Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado, 80225 or call (303) 236-7476. Network Bulletins will be published only in *Seismological Research Letters* starting with the 1997 Bulletin. Network Bulletins for 1990 through the present can also be seen without figures at http://www-socal.wr.usgs.gov/lisa/NETBULLS. Archived SCSN data and information about getting an account on the SCEC Data Center can be obtained at http://www.scecdc.scec.org.

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APPENDIX A

Significant Southern California Earthquakes

All events of $M_L \geq 3.0$ for the period January to December 1997. Times are GMT, Q is the overall quality of the location, M is the magnitude, Z is the depth in km, PH is the number of phases picked, RMS is the root mean square of the location error, ID is the unique number assigned to the event by the CUSP system, and F denotes the number of the accompanying focal mechanism in Figure 6. Note that these events have not been finalized; therefore, their magnitudes may not be of the highest accuracy. In most cases, if the magnitude is incorrect, it is larger than indicated.

APPENDIX A

Date			Time			Location				Q	M	Z	PH	RMS	ID	F
1997	1	4	14	58	35.11	36°	4.05′	−117°	38.85′	A	4.0	1.19	72	0.17	7055262	
1997	1	4	15	25	27.29	36°	3.82′	−117°	38.65′	A	3.5	1.44	61	0.17	7055269	
1997	1	9	9	1	54.23	34°	22.24′	−116°	27.75′	A	3.1	2.93	106	0.18	7055744	
1997	1	12	0	1	48.31	36°	3.48′	−117°	38.34′	A	3.5	0.82	58	0.19	7056116	
1997	1	13	11	29	37.65	33°	26.84′	−116°	54.07′	A	3.8	13.38	119	0.24	7056254	
1997	1	13	16	9	34.82	33°	16.03′	−116°	0.57′	A	3.9	3.63	67	0.23	7056275	
1997	1	15	16	17	19.38	33°	49.14′	−117°	0.09′	A	3.3	12.55	115	0.26	7056485	
1997	1	18	0	11	30.71	34°	9.47′	−116°	25.45′	A	3.3	1.27	90	0.20	7056750	
1997	1	18	0	44	8.52	34°	21.30′	−118°	44.40′	A	3.0	16.81	61	0.22	7056758	
1997	1	22	2	40	19.83	35°	4.73′	−118°	56.81′	A	3.3	10.63	100	0.27	7057163	
1997	1	24	18	27	51.84	34°	13.40′	−117°	25.86′	A	3.2	12.72	107	0.21	7057447	
1997	1	30	18	48	21.02	36°	4.89′	−117°	38.05′	A	3.2	1.19	49	0.19	7057995	
1997	1	31	12	25	41.01	33°	54.74′	−117°	47.04′	A	3.5	8.75	136	0.29	7058066	
1997	2	2	0	19	15.44	32°	37.33′	−115°	55.08′	A	3.7	12.47	62	0.39	7058289	
1997	2	2	2	20	20.87	36°	11.06′	−120°	11.23′	C	4.0	6.00	29	0.38	7058285	

Date			Time			Location				Q	M	Z	PH	RMS	ID	F
APPENDIX A (CONTINUED)																
1997	2	3	11	4	14.39	34°	18.01′	−118°	34.05′	A	3.4	2.28	129	0.32	7058393	
1997	2	7	6	59	49.65	33°	30.08′	−116°	33.81′	C	3.9	6.00	92	0.27	7058741	
1997	2	12	3	5	1.25	32°	37.45′	−115°	55.14′	A	3.6	5.81	32	0.32	7059166	
1997	2	12	12	24	55.08	32°	37.63′	−115°	54.92′	A	3.0	6.00	30	0.27	7059203	
1997	2	15	4	22	10.18	36°	4.32′	−117°	38.02′	A	3.9	2.74	53	0.21	7059434	
1997	2	15	8	13	47.96	36°	5.06′	−117°	38.21′	A	3.7	3.63	58	0.20	7059487	
1997	2	15	14	11	8.48	36°	4.93′	−117°	38.00′	A	3.2	3.53	40	0.16	7059538	
1997	2	15	15	14	54.07	34°	0.14′	−117°	34.75′	A	3.1	3.00	104	0.20	7059548	
1997	2	21	13	23	25.07	34°	23.81′	−119°	41.84′	A	3.5	2.19	85	0.44	7060017	
1997	2	23	3	43	33.17	33°	44.29′	−116°	2.57′	A	3.9	7.45	93	0.17	7060200	
1997	2	23	3	44	59.22	33°	44.30′	−116°	2.60′	A	3.4	7.20	62	0.18	7060205	
1997	2	23	3	48	51.15	33°	44.27′	−116°	2.47′	A	3.3	7.71	79	0.19	7060203	
1997	2	25	5	38	52.96	35°	40.67′	−118°	6.41′	A	3.1	2.40	73	0.16	7060397	
1997	2	26	8	55	10.50	34°	24.33′	−120°	45.83′	C	3.1	6.00	26	0.33	7060478	
1997	2	26	9	3	3.67	34°	26.73′	−120°	42.76′	C	3.3	6.00	36	0.34	7060479	
1997	3	8	15	36	51.88	36°	5.52′	−117°	39.86′	A	3.6	1.07	51	0.19	7061511	
1997	3	18	9	47	40.41	34°	58.15′	−116°	49.44′	A	3.1	1.12	59	0.20	7062489	
1997	3	18	15	24	47.72	34°	58.24′	−116°	49.11′	A	5.3	1.66	181	0.27	7062511	1
1997	3	18	16	19	23.09	34°	58.28′	−116°	49.55′	A	3.8	1.01	98	0.21	7062535	
1997	3	18	16	40	14.60	34°	58.42′	−116°	49.21′	A	3.4	0.00	59	0.22	7062504	
1997	3	18	21	28	54.17	34°	58.15′	−116°	49.62′	A	3.1	0.53	61	0.23	7062564	
1997	3	19	4	45	19.05	34°	58.12′	−116°	49.31′	A	3.4	0.01	117	0.25	7062610	
1997	3	20	18	12	36.48	33°	48.44′	−116°	58.34′	A	3.1	13.04	102	0.20	7062796	
1997	3	30	8	24	3.34	33°	8.57′	−118°	40.42′	B	3.4	9.44	82	0.31	7063780	
1997	4	1	18	3	54.47	33°	2.33′	−116°	30.16′	A	3.0	3.10	54	0.35	7063953	
1997	4	3	7	30	42.81	34°	26.29′	−120°	43.33′	B	3.0	0.01	25	0.30	7064079	
1997	4	4	9	26	24.55	33°	58.97′	−118°	21.26′	A	3.3	4.24	61	0.30	7064227	
1997	4	6	11	41	11.53	33°	25.34′	−116°	57.04′	A	3.2	11.65	114	0.23	7064394	
1997	4	21	7	38	47.04	34°	58.52′	−116°	48.74′	A	3.6	0.76	83	0.20	9008328	
1997	4	26	10	37	30.67	34°	22.15′	−118°	40.20′	A	5.1	16.45	183	0.27	9008753	2
1997	4	26	10	40	29.78	34°	22.49′	−118°	40.24′	A	4.0	14.61	142	0.26	3295648	
1997	4	26	10	54	30.79	34°	22.55′	−118°	39.08′	A	3.1	15.15	95	0.23	9008746	
1997	4	26	11	8	55.46	34°	22.85′	−118°	38.77′	A	3.1	14.00	79	0.26	9008769	
1997	4	26	11	10	4.60	34°	22.46′	−118°	39.04′	A	3.0	14.82	84	0.23	9008779	
1997	4	26	11	33	37.85	34°	22.51′	−118°	38.58′	A	3.1	14.03	82	0.22	9008757	
1997	4	26	11	55	47.51	34°	22.40′	−118°	39.93′	A	3.8	15.20	137	0.30	9008791	
1997	4	26	16	13	42.84	34°	21.96′	−118°	40.97′	A	3.4	16.97	113	0.23	9008832	
1997	4	27	11	9	28.38	34°	22.63′	−118°	38.95′	A	4.8	15.18	174	0.25	9008934	3
1997	4	27	11	31	20.88	34°	22.78′	−118°	38.49′	A	3.6	13.83	98	0.22	9008951	
1997	4	27	11	31	21.05	34°	23.76′	−118°	39.32′	A	3.4	13.40	176	0.44	9008940	
1997	4	27	11	31	51.22	34°	22.34′	−118°	38.83′	A	3.7	14.58	34	0.20	3295658	
1997	4	27	15	18	34.98	34°	22.72′	−118°	38.06′	A	3.4	15.33	111	0.26	9009010	

APPENDIX A (CONTINUED)																
Date			Time			Location				Q	M	Z	PH	RMS	ID	F
1997	4	27	18	23	42.26	36°	0.86′	−118°	26.81′	C	3.0	6.00	52	0.14	9009038	
1997	4	28	1	20	37.91	34°	23.04′	−118°	38.49′	A	3.0	13.66	63	0.22	9009062	
1997	5	3	12	51	48.00	34°	22.31′	−118°	40.15′	A	3.5	15.36	100	0.23	9009589	
1997	5	6	18	53	22.80	34°	58.30′	−116°	48.65′	A	3.2	0.96	69	0.19	9009836	
1997	5	6	19	12	53.76	35°	27.16′	−118°	25.88′	A	4.5	5.99	151	0.25	9009850	4
1997	5	8	6	59	4.82	35°	43.66′	−117°	37.47′	B	3.0	5.98	65	0.16	9009965	
1997	5	11	0	16	28.61	33°	58.42′	−116°	40.30′	A	3.8	16.49	130	0.21	9010203	
1997	5	15	13	31	53.20	34°	22.32′	−116°	52.65′	A	3.1	4.15	81	0.19	9010627	
1997	5	15	14	29	2.64	33°	52.72′	−118°	27.62′	A	3.1	9.54	88	0.29	9010637	
1997	5	16	10	34	36.94	32°	13.70′	−116°	41.53′	D	3.2	6.00	35	0.30	9010708	
1997	5	18	21	45	33.50	34°	48.85′	−120°	18.51′	B	3.1	1.35	27	0.26	9010927	
1997	5	21	14	7	4.06	32°	11.53′	−115°	46.30′	D	3.3	6.00	7	0.13	9011161	
1997	5	22	19	25	21.25	32°	16.15′	−116°	39.98′	C	3.2	6.00	32	0.30	9011285	
1997	5	23	6	48	32.12	34°	58.35′	−116°	48.57′	A	3.6	0.86	98	0.21	9011341	
1997	5	23	12	22	1.03	34°	57.94′	−116°	49.03′	A	3.5	1.74	110	0.23	9011364	
1997	5	23	13	22	1.85	34°	58.37′	−116°	48.44′	A	3.3	1.15	83	0.20	9011370	
1997	5	23	14	38	41.69	33°	4.19′	−116°	27.53′	A	3.5	13.74	69	0.27	9011379	
1997	5	24	4	36	13.26	35°	47.80′	−117°	38.25′	A	3.9	5.28	96	0.17	9011429	
1997	5	29	0	48	14.95	33°	20.83′	−116°	54.72′	A	3.4	6.91	91	0.24	9011839	
1997	6	10	1	2	40.09	35°	59.01′	−117°	40.25′	A	3.4	2.43	73	0.17	9012920	
1997	6	10	9	21	45.49	34°	2.89′	−117°	15.92′	A	3.2	15.27	131	0.23	9012932	
1997	6	13	11	16	18.78	32°	36.35′	−115°	52.06′	C	3.4	13.69	29	0.22	9013137	
1997	6	20	4	35	40.52	32°	40.86′	−118°	6.54′	C	4.8	6.00	127	0.45	9013612	5
1997	6	20	5	38	55.01	32°	41.08′	−118°	8.25′	C	4.2	6.00	67	0.49	9013626	6
1997	6	20	8	4	13.62	32°	37.55′	−118°	9.04′	C	4.5	6.00	120	0.54	9013640	7
1997	6	20	11	17	40.96	32°	43.25′	−118°	7.95′	C	3.5	6.00	71	0.46	9013656	
1997	6	23	7	57	27.20	32°	44.03′	−115°	25.92′	A	3.5	16.13	39	0.30	9013950	
1997	6	24	4	48	58.01	35°	16.56′	−118°	35.66′	A	3.4	5.36	93	0.21	9014038	
1997	6	27	14	6	20.39	33°	15.78′	−116°	0.34′	A	3.4	3.34	63	0.23	9014370	
1997	6	27	20	17	45.85	35°	26.54′	−118°	18.64′	B	3.7	5.50	84	0.14	9014396	
1997	6	28	21	45	25.10	34°	10.11′	−117°	20.17′	A	4.2	10.03	177	0.26	9014489	8
1997	6	30	1	5	31.23	34°	58.26′	−116°	48.77′	A	3.4	0.56	71	0.20	9014547	
1997	6	30	1	28	56.25	34°	58.30′	−116°	48.90′	A	3.2	0.91	82	0.21	9014549	
1997	7	1	17	37	52.52	35°	47.63′	−117°	38.17′	A	3.1	5.27	49	0.16	9014676	
1997	7	2	13	52	43.54	36°	5.75′	−117°	40.00′	A	3.2	1.29	56	0.17	9014794	
1997	7	3	17	49	37.58	35°	47.48′	−117°	38.26′	A	4.3	4.68	94	0.18	9014887	9
1997	7	3	19	17	50.97	32°	11.59′	−115°	24.69′	D	3.5	6.00	24	0.52	9014900	
1997	7	5	12	42	38.30	32°	42.73′	−115°	24.95′	A	3.5	19.80	36	0.29	3296374	
1997	7	11	6	40	23.02	34°	28.50′	−118°	4.86′	A	3.0	9.86	106	0.23	9015828	
1997	7	12	18	5	40.76	34°	9.36′	−117°	19.66′	A	3.5	10.28	114	0.25	9015982	
1997	7	13	19	41	6.24	32°	5.41′	−114°	59.84′	D	3.0	6.00	15	0.36	9016116	
1997	7	14	10	20	37.51	32°	37.87′	−115°	54.21′	A	3.2	6.02	42	0.36	9016179	

APPENDIX A (CONTINUED)

Date			Time			Location				Q	M	Z	PH	RMS	ID	F
1997	10	16	9	37	54.60	34°	1.22′	−116°	44.94′	A	3.1	13.33	94	0.18	9026626	
1997	10	16	16	2	29.79	34°	13.46′	−118°	37.22′	A	3.0	3.38	111	0.33	9026670	
1997	10	18	20	57	16.13	33°	25.11′	−118°	44.63′	A	3.4	10.26	68	0.37	9026968	
1997	10	23	18	58	30.91	34°	58.61′	−116°	57.29′	A	3.0	5.46	71	0.20	9027779	
1997	10	26	4	2	40.94	34°	15.27′	−118°	42.37′	A	3.1	14.16	115	0.30	9028147	
1997	10	27	16	41	15.08	33°	10.56′	−116°	2.32′	A	3.2	11.37	71	0.26	9028384	
1997	10	28	4	6	57.99	35°	26.92′	−118°	25.93′	A	3.4	7.26	94	0.19	9028521	
1997	11	4	14	36	21.77	34°	6.25′	−117°	25.82′	A	3.6	4.42	153	0.22	9029821	
1997	11	4	22	43	16.44	32°	40.48′	−118°	2.78′	C	3.4	6.00	48	0.46	9029878	
1997	11	6	4	33	43.46	34°	58.73′	−116°	57.02′	A	3.8	5.19	87	0.17	9030140	
1997	11	7	16	32	26.96	35°	44.78′	−117°	37.30′	A	3.0	4.71	51	0.19	9030353	
1997	11	14	6	53	28.90	35°	39.45′	−118°	16.32′	A	3.6	11.64	45	0.16	9031252	
1997	11	18	13	48	0.64	32°	10.51′	−115°	22.59′	C	3.1	6.00	19	0.39	9031620	
1997	11	26	5	56	28.74	32°	42.08′	−118°	6.92′	D	3.5	6.00	25	0.38	9032784	
1997	11	28	14	51	37.98	32°	16.42′	−115°	18.04′	C	3.7	6.00	33	0.44	9032954	
1997	12	4	8	30	57.37	33°	9.76′	−115°	39.31′	A	3.4	2.40	49	0.32	9033605	
1997	12	5	17	4	38.92	34°	5.80′	−116°	59.74′	A	4.1	4.47	171	0.34	9033757	13
1997	12	6	10	34	52.08	36°	23.64′	−120°	15.98′	C	3.6	6.00	18	0.28	9033885	
1997	12	9	1	10	12.62	32°	20.24′	−115°	15.81′	C	4.0	6.00	30	0.42	9034200	
1997	12	9	14	30	57.78	36°	18.95′	−120°	22.68′	C	3.3	6.00	29	0.37	9034226	
1997	12	10	13	25	18.51	32°	28.48′	−115°	23.16′	C	3.0	6.00	27	0.32	9034334	
1997	12	12	11	36	15.57	36°	6.73′	−120°	13.03′	C	3.4	6.00	26	0.36	9034725	
1997	12	19	7	7	1.29	36°	27.36′	−117°	39.52′	C	3.7	6.00	48	0.30	9035535	
1997	12	22	14	45	4.37	32°	0.34′	−116°	21.87′	C	3.2	6.00	12	0.13	9035948	
1997	12	26	15	5	32.29	33°	19.23′	−115°	41.34′	A	3.7	10.15	74	0.34	9036250	
1997	12	27	16	56	41.47	33°	19.10′	−115°	41.58′	A	3.2	3.84	67	0.39	9036406	
1997	12	31	12	22	45.05	33°	11.52′	−115°	36.47′	A	4.1	10.21	68	0.36	9036954	14
1997	12	31	13	5	46.28	33°	11.55′	−115°	36.61′	A	3.1	5.50	30	0.29	9037000	