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THE SOUTHERN CALIFORNIA NETWORK BULLETIN

JANUARY THROUGH JUNE, 1986

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by

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I. INTRODUCTION

During the first six months of 1986 the Southern California Seismic Network continued in a state of transition. The changes to telemetry, on-line recording of digital seismic data, and off-line data processing that were planned in 1985 were being gradually implemented. Some were completed during this period, while others await further development.

The period of very low seismicity that began in November 1985 continued through February of this year, but the period from March through June had a level closer to normal. There was one event of magnitude 4.0 during this six-month period.

On June 30 Dr. Carl Johnson, the architect of southern California network computer processing, transferred to the Hawaiian Volcano Observatory (HVO) after seven and a half years at the Pasadena office of the USGS. He will continue to be involved in the evolution of the CUSP data acquisition system which is now in use at HVO as well as in central and southern California.

II. EARTHQUAKE DATA PROCESSING, JANUARY 1 THROUGH JUNE 30, 1986

The CUSP data acquisition and processing system (Johnson, 1983) has been brought into full operation on the new VAX off-line processing computer. For a full discussion of data processing see Norris et al., (1986). The daily processing effort focused simultaneously on current data and the August - December 1985 backlog (Norris et al., 1986b). In spite of the extra work added by the backlog data, most of the earthquakes that were recorded by the on-line system in the first half of 1986 were located within a few days of their occurrence. By the end of the period the 1985 backlog has been reduced from 18 weeks to seven weeks.

Seismic signals for most stations in the array are routinely recorded on analog "FM" tapes. Sections of these daily tapes that hold earthquakes and teleseisms are routinely dubbed from these magnetic tapes and archived in the Menlo Park office of the USGS. During the reporting period, however, this dubbing system was interrupted because of a shortage of blank tapes. Consequently, analog data for the periods of May 10-30 and June 20-24 were not preserved. A full explanation of this system appears in Norris et al., (1986a). Inquiries about these data should be directed to Jack Tomey in the Menlo Park office at (415) 323-8111, ext. 2632.

In June of 1986, new on-line software was installed on the computers that detect and record earthquakes in the Southern California Seismic Network. No changes in the hardware have been made; the on-line system continues to run on twin PDP 11/34's, each with a Tustin A/D converter and one RA81 disk drive.

The new software was designed to be compatible with the CUSP (Caltech/USGS Seismic Processor) off-line data processing software (Johnson, 1979, 1983). The new software offers a number of advantages over the old version:

- The program modules are "swappable", allowing Digital Equipment Corporation (DEC) DECNet software to run simultaneously. Use of DECNet allows data to be transferred from the on-line computers to the off-line processing computer electronically, over an Ethernet link.

- The system will accept up to 300 channels of input.

- The specification and modification of the channel identification, subnet configuration and triggering parameters is easier.

- Console output is more concise.

- Only traces which record energy or are close to the event are saved, reducing the amount of disk storage used for each event.

There are also some disadvantages, compared to the old system:

- The new system detects fewer very small earthquakes than the old one.

- Non-triggered stations outside of triggered subnets are not saved.

The new on-line code differs from older systems in that it is divided into modules that can be "swapped" in and out of the limited available memory. Only those program modules that interact with the A/D converter remain in memory permanently. The modules themselves are very similar to those written by Johnson for the Seismic network at HVO. However, the HVO on-line computer (a VAX 750) has sufficient virtual memory to allow all the modules to remain resident in memory. On our smaller 11/34 systems it is necessary to make them swap out of memory onto disk periodically to make room for the DECNet software. In theory, the DECNet/Ethernet link allows near real-time earthquake locations, because event files can be transferred to the off-line VAX 750 for processing immediately after they are recorded.

Figure 1 illustrates the on-line program modules and their interactions. The real-time part of the system (SCARAB) continuously writes data from the A/D converter into two alternating, temporary buffers in memory and then to a circular buffer (TANK.DAT) on the RA81 disk drive. (Mnemonically speaking, there are two "bugs" in the on-line system. One is SCARAB, a dung beetle which rolls balls of data into the TANK.DAT file. The other is SPIDER which sits in the middle of its web ,the Network, and detects motion around it.) All of the other modules, including event detection, run as memory becomes available. The programs have approximately 30 minutes to complete their work on the data in the buffer before it is over-written by new data.

The event detection module, SPIDER, swaps in every 10 seconds. SPIDER is similar to the detection process on the previous system. 84 overlapping subnets of from seven to 10 stations have been defined to optimize detection in particular geographic area. If the short-term average (5 seconds) of the amplitude exceeds the long-term average (60 seconds) by a pre-determined factor (currently 2.0) on four stations in a subnet for a predetermined period of time (8 seconds), that subnet and, consequently, the on-line system, is triggered. Buffered data for the 30 second period before the trigger are recorded to insure that early P arrivals are not lost and data continue to be recorded until 20 seconds after all subnets become "detriggered". All of these numbers are parameters in the file WEB.MEM which can easily be adjusted.

Only data from triggered stations and from untriggered stations that are members of triggered subnets are saved. (Subnets may have "silent" members, such as weak stations or low-gain or horizontal components, which do not participate in the triggering but are saved when the subnet is triggered.) Recording only stations in triggered subnets reduces the volume of data that is transferred over the DECNet, which significantly decreases disk storage and drain on system resources. This network information is stored in the files NET.DCK and WEB.DCK.

After an event has been detected, SPIDER writes 16 blocks of data to an event file with the specification Xn.EVT, where 'n' is a unique sequence number. This number, the "CUSP ID", will uniquely identify each event as it moves through off-line processing. This 16-block header contains information about the start and stop times of the trigger, its place in the buffer, and the subnets that are to saved. Another program, SLING, then swaps in and stays in memory long enough to write the multiplex seismogram data from the TANK.DAT to the Xn.EVT file. Only when it has finished can SPIDER swap back in again. If all is well, SPIDER has time to look for earthquakes in the data that SCARAB has added to the TANK.DAT during the time SPIDER was swapped out. When SPIDER is finished, SLING gets its turn to finish any more Xn.EVT files that SPIDER might have created. These modules continue to swap in and out of memory, each doing its part of the on-line detection and recording task.

In practice, SPIDER may not run fast enough on 100 Hz data from 256 stations to leave SLING enough CPU time to do its work. A typical small seismic event (magnitude 1.0 to 2.0) takes four to six minutes for SLING to process, from trigger time until the final close of the Xn.EVT file. This total processing time, which includes the length of the trigger itself, is referred to as the "latancy" time. During this time raw network data is being written into the TANK.DAT by SCARAB. A few small events in close succession will drive the latancy time to greater than 30 minutes, and the TANK.DAT buffer will wrap around causing unprocessed data to be lost.

To speed up SPIDER, only every forth block of data in the TANK.DAT is used to calculate amplitude averages for event detection. At 100 hz digitization rate, about 1/4 second out of every second is used. Under this regime an event that keeps a particular station triggered for less than 3/4 second may be missed by SPIDER. Therefore, the probability of detection of very small events is diminished.

In the early stages of testing, the old on-line software was run side-by-side with the new version, on the twin 11/34's. Many events shorter than 10 seconds coda duration which triggered the old system were missed by the new one. A few events up to 15 seconds duration were missed, depending on their location in the Network. No local events longer than 15 seconds duration were missed. This sacrifice of small events was considered a reasonable price for the near real-time advantages of the new code. We expect to see the annual total of local events recorded by the Network to drop from about 15,000 to about 10,000.

The finished Xn.EVT files may be retrieved from the on-line system in two ways. A batch procedure (HARVST) runs every 10 minutes on the off-line VAX 750 and copies any new Xn.EVT files over the Ethernet from the on-line machine. On the VAX the new event is scheduled for demultiplexing (DEMULT) and another batch process demultiplexes the data and creates the Xn.MEM file and Xn.GRM files that are necessary for CUSP processing. Both HARVST and DEMULT run in indefinite loops, waking up every 10 minutes to look for new events. In addition, all Xn.EVT files are written to tape from the 11/34 using a module called FLING, which also deletes them from the disk. As a precaution, both on-line systems are "flung" at least once every day, but only the one designated as the primary on-line system, is looked at by HARVST. If the primary system should go down, events are loaded onto the VAX from FLING tapes made on the secondary system.

At the operator's discretion, a software P-picker can also be run on the off-line computer as an indefinite loop batch process. In general, the P-picker is slower than a human at a graphics terminal and less accurate, but it has the advantage of being able to work all night without coffee. During periods of average seismicity, a completely automatic preliminary location is available 20 to 30 minutes after the occurrence of the earthquake. This is approximately the response time of a seismologist at night, so the location is available at about the time the seismologist arrives. The operator may look at the event on a graphics terminal using the usual CUSP software at any time after DEMULT has finished.

Less than two weeks after both 11/34's began running the new code, the system received a severe test. On July 8, an area of dense station coverage in the middle of the Network near North Palm Springs, experienced a M_L 5.6 event with attendant aftershocks. (This earthquake will be discussed in the next edition of this Bulletin). Approximately 1654 events should have been detected in the first six hours of the sequence. In fact, the TANK.DAT buffer wrapped around on both systems within 40 minutes due to the intense aftershock activity and stayed that way until the systems were shut down and restarted four hours later. During this time, only fragmentary sections of digital data were recorded. (It is hoped that digital data can be recovered from analog tape backups in the near future.)

Following that experience, it was decided to run the secondary system at a digitization rate of 62.5 Hz. This is the rate that was used on the previous system. The detection threshold is further degraded under this regime, because the time period between every fourth block is longer. However, to date no significant earthquakes have been missed, and the primary system, which still runs at 100 Hz, is preferentially used. This arrangement has the added advantage that more events will fit onto the disk on the secondary system, making it a more reliable backup during periods of high seismicity.

This new scheme was quickly put to the test on July 13 by a M_L 5.3 shock about 28 miles offshore near Oceanside that was followed by an unusually vigorous aftershock sequence. (This earthquake will be discussed in the next edition of this Bulletin). This sequence did not load the system as severely as the one on July 8, but it did wrap around the buffer on the primary 11/34 during the aftershock sequence. The secondary system performed well, however, and the primary was stopped and restarted immediately, so no data were lost.

From the point of view of data processing speed and efficiency, the new software is an improvement over the old. In particular, the off-line CUSP software used to expend a large amount of CPU time demultiplexing seismograms that were too far away from the triggering event to show any energy whatsoever. Furthermore, when all is working well, much of the demultiplexing happens automatically at night. A small but significant amount of time was also expended demultiplexing and timing events less than M_C 1.0, which now are not recorded at all.

In addition to simplifying the task of data collection and giving us a real-time capability it is hoped that the new on-line sytem will translate into better and faster availability of digital data for the researchers.

III. NETWORK OPERATION, JANUARY 1 THROUGH JUNE 30, 1986

Major changes to station electronics and telemetry are taking place this year. Sections of this and subsequent bulletins will be devoted to reporting and explaining those changes. Table 1 provides a description of the equipment installed at each remote site and the discriminator type at the Seismological Laboratory in Pasadena. This table summarizes the state of the Network prior to the modifications planned for 1986, and will be updated in future Bulletins as changes occur. Stewart and O'Neill (1980) give a FORTRAN program that can be used to calculate the response of any instrument in the USGS networks from the poles of the individual conponents (ie. seismometer, amplifier/VCO, discriminator). Their Tables 2-4 list the parameters needed to calculate the response of most of the devices in use today except certain discriminators. Table 2 of this report lists the parameters for these additional discriminators. We have used the notation of Stewart and O'Neill (1980). Discriminators of the type J101M, J110, 6243, and 6203 do not vary among themselves. The J101 discriminators all have response curves with the same shape but with different corners. Therefore, for these discriminators the additional information of their 70% level is given in Tables 2. The corner frequencies for these discriminators are given in parentheses in column two of Table 1. As the corner moves from one value to another, linear interpolation can be used to calculate the new pole positions. See the values in Table 2 for examples. Following Stewart and O'Neill (1980), the absolute gain at any instrument is the product of the following factors:

$$\text{Gain} = G_{LE} \cdot G_{SA} \cdot D_{VCO} \cdot D_{DSC} \cdot L$$

where

$$G_{LE} = 1.0 \frac{\text{volt}}{\text{cm/sec}}$$

$$G_{SA} = 10^{\frac{(90.4 - \text{attn})}{20}}$$ (See Table 3 of Stewart and O'Neill (1980) for exact value)

$$D_{VCO} = 37.04 \frac{\text{Hz}}{\text{volt}}$$

$$D_{DSC} = \frac{\text{Disc.} \pm \text{Voltage}}{125 \text{ Hz}}$$ (Values given in Table 1)

$$L = 819.2 \frac{\text{counts}}{\text{volt}}$$

This information is sufficient to define the response of each instrument. A list of station locations and installation dates appears in Norris et al. (1986a).

The Network station configuration did not change during the period (Figure 2). Four new sites are planned for the Victorville area to replace current stations that are frequent targets of vandalism; Round Mountain (RDM) and Rodman Mountain (ROD). A temporary shortage of Network technicians during the first half of 1986 lead to a higher incidence of station outages than normal.

Fifty new J502 voltage controlled oscillators (VCO) are being assembled and prepared for installation. As of June 30, they had been installed at two stations (ADL and ELM). The new components will improve the signal to noise ratio at sites where they are installed.

Most of the VCO's used at Network stations generate a calibration pulse at 24 hour intervals. Because of the recent modifications to the on-line system discussed above, it will soon be possible to routinely examine these calibration pulses. The pulses contain coded information about the VCO type and attenuation setting, and tests of internal electronics and the damping of the seismometer. These data will be useful for calibration of the network stations and studies requiring information about instrument response.

The construction of the microwave telemetry system was completed in 1985, and in May 1986 a testing program began on the string of relay stations between Edwards Air Force Base in the Mojave Desert and the Seismological Laboratory. Other segments of the microwave system may be activated sometime later this year. When it is completely operational the system will carry the signals from almost half of all USGS-operated stations in southern California.

Together Caltech, the University of Southern California (USC), and the Pasadena Field Office of the USGS have agreed to develop a very-broad-band seismic recording system. The system is based on a 3-component Streckeisen seismometer and Kinemetrics force-balance accelerometers located at the Kresge observatory (PAS) in the San Raphael Hills of Pasadena. It will provide near real-time access to absolute ground motion ranging from the ambient noise level to 2g (more than 160 db) over a frequency range from 10 to 0.001 Hz. Data will be digitally telemetered to the Caltech VAX/750. A digital data logger developed and built by Joseph Steim of Harvard University will be installed at the Kresge site. This data logger is built around a Motorola 68020 processor and a VME data bus. A full description of the system is given by Steim (1986). Installation of the Streckeisen seismometers is scheduled for fall of 1986 and the data logger should be installed in the winter.

IV. SYNOPSIS OF SEISMICITY, JANUARY 1 THROUGH JUNE 30, 1986

Southern California earthquake activity was very low during the first half of 1986, continuing a trend that began in November of 1985. During the reporting period, 6144 earthquakes were located in and around the Network (Figure 3), however, only 54 of these events were greater than or equal to magnitude 3.0 (Table 3). This is the lowest rate of activity at that magnitude level since the beginning of 1981. There were 101 events in that magnitude range in the preceeding six months. Felt reports were received for 17 events. The largest earthquake within the Network was a magnitude 4.0 event 12 km west of Santa Barbara on March 10th.

In order to consider the seismicity of southern California in more detail the region has been divided into eleven sub-regions following the example of Allen (unpublised data) (Figure 5). This same scheme was used in earlier Bulletins (Norris, 1986a, b). These sub-regions are somewhat arbitrary, but generally delineate broad structural and geologic bounds. The cumulative seismicity plots shown in Figures 6a and 6b refer to these sub-regions. The charts show the cumulative count of all earthquakes greater than or equal to magnitude 2.5 in each region for a four year period ending June 30, 1986. They also show individual quakes of magnitude greater than or equal to 4.0. The plots provide a context in which to consider the seismic activity of the latest six-month period. The activity of some of the more active sub-regions is discussed below.

<u>SAN BERNARDINO</u> Several large events occurred in this region during the reporting period (Figure 7). A magnitude 3.8 event occurred near the east end of the Pinto Mountain fault on February 17. On May 31 a magnitude 3.5 event occurred at the west end of that fault zone where it splays and joins the Mission Creek strand of the San Andreas fault zone.

Five quakes greater than magnitude 3.0 occurred along the complex segment of the San Andreas fault zone between San Bernardino and the Palm Springs area. Focal mechanisms for two of these quakes indicate oblique reverse slip (Figure 7).

On April 5 a notable event occurred at the southern end of the San Andreas fault near Bombay Beach. This magnitude 3.7 earthquake resulted from right-lateral strike-slip on a plane striking N30°W, a trend that agrees with the strike of the San Andreas fault at the surface (Figure 8). The event occurred where the southernmost extension of the San Andreas fault zone joins the northern end of the Brawley seismic zone. This event is especially interesting because events of that size are not common in this area and it is possible that this area will be the point of nucleation for a large quake on the southern San Andreas fault.

IMPERIAL VALLEY Two minor earthquake swarms occurred in the Brawley seismic zone. The Brawley seismic zone is a 50 km long band of high seismicity that stretches from the southernmost mapped trace of the San Andreas fault to the northern tip of the Imperial fault. No mapped fault is associated with this trend. Earthquake swarms are typical in the area but have been much less frequent since the magnitude 6.4 earthquake near Calexico in October 1979. The first swarm began on February 17 and included events of magnitude 3.4 and 3.1. The second swarm began on April 24 and included a quake of magnitude 3.0 (Figure 9). Focal mechanisms for the largest member of each swarm indicate right-lateral strike-slip movement on planes parallel to the trend of the San Andreas fault but more westerly trending than the trend of the Brawly seismic zone (Figure 8).

L.A. COAST Activity in the Los Angeles Basin was unusually high during the reporting period (Figure 9). A magnitude 3.3 quake was felt in Torrance on March 20. On April 5 a magnitude 3.9 event occurred in Long Beach near the epicenter of the Long Beach earthquake of 1933 (M_L = 6.3). Its focal mechanism indicates right-lateral strike-slip on a plane parallel to the Newport-Inglewood fault zone. Two quakes rocked Manhattan Beach, a magnitude 3.1 event on May 19 and a 3.6 quake on June 3. Both yield mechanisms showing oblique reverse slip.

NORTH ELSINORE Two earthquakes larger than magnitude 3.0 occurred within a week of one another in this region. The first was a magnitude 3.3 quake on March 3 near the junction of the Elsinore and Whittier faults. The second, a magnitude 3.5 quake, occurred six days later near Claremont (Figure 9).

SANTA BARBARA The Ventura-Santa Barbara coastal region has been unusually active since May 1984 (Norris et al., 1986a). This activity is evident in the steepening of the cumulative seismicity curve for this region beginning at that time (Figure 6b). Although the first six months of 1986 have been quieter than most of 1985, a magnitude 4.0 event and a 3.0 aftershock occurred 12 km west of Santa Barbara on March 10 (Figure 9).

SOUTHERN SIERRA A large event occurred on May 23 in the southern Sierra Nevada at the site of the 1946 Walker Pass earthquake (M_L = 6.3). The magnitude 3.9 event shows a focal mechanism indicative of normal faulting on a north-south plane (Figure 10).

ACKNOWLEDGEMENTS

The operation of the Southern California Seismic Network is shared by many people. The raw data is processed and archived by Riley Geary, Kathy Watts, Steven Bryant and Ruth Hanna. Their dedication insures the consistant high quality of the earthquake catalog. The integrity of the Network telemetry is maintained by Charles Koesterer, Gary Cone, Jim Marietta, Bill Curtis, and David Johnson who must often overcome tremendous obstacles to keep us "on the air". Caltech's part of the Network operation is funded, in part, by USGS Cooperative Agreement #14-08-0001-A0257.

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Table 1: Station Telemetry Components

CODE	STATION NAME	DISC. TYPE	DISC. ±VOLTAGE	VCO	ATTN
ABL	MOUNT ABEL	J101M	2.84	J1	12
ADL	ADELANTO	J101M	2.95	J5	24
AMS	AMOS	J101M	3.05	J3	6
ARV	ARVIN	J110	2.47	J4	12
BAR	BARRETT DAM	J101M	2.50	--	--
BAT	BAT CAVE BUTTE	J101M	2.55	J1	18
BC2	BIG CHUCKWALLA MTN	J101M	2.88	J1	6
BCH	BRANCH MTN	J101M	2.80	J3	6
BLK	BLACK MTN	J110	2.53	J4	6
BLU	BLUE RIDGE	J110	2.00	J2	12
BLUV	BLUE RIDGE	J101M	2.90	J4	48
BMT	BEAR MTN	J101M	2.56	J2	6
BOO	SOUTH BASE BOOSTER	J101M	2.78	J4	24
BON	BONDS CORNER	J101M	1.72	J1	30
BRG	BORREGO MTN	J110	2.51	J4	6
BRT	BERTELL RANCH	J101M	2.88	J4	18
BTL	BUTLER PEAK	J101M	2.98	J1	12
CAH	CAHUILLA VALLEY	J101M	2.79	J4	12
CAL	CALIFORNIA CITY	J101 (32)	2.69	J3	12
CAV	CAVE MTN	J101M	2.92	J4	0
CBK	CANEBRAKE	J101M	2.81	J4	6
CFT	CRAFTON HILLS	J101M	2.66	J3	24
CH2	CHOCOLATE MTNS	J101M	2.97	J2	0
CIS	SANTA CATALINA IS.	6243	2.67	--	--
CJV	CASA JUVAN	J101M	2.44	J4	18
CLI	CALIPATRIA	J110	3.36	J1	24
CO2	COXCOMB MTN	J101M	3.59	J1	0
COA	COACHELLA	J101M	2.83	J2	24
COK	COOK RANCH	J101M	2.81	J1	24
COY	COYOTE MTN	J101M	2.78	J2	6
COYV	COYOTE MTN	J101M	2.07	J4	48
CPE	CAMP ELLIOT	J101 (20)	1.99	--	--
CPM	COPPER MTN	J101M	2.01	J4	6
CPMV	COPPER MTN	J101M	2.11	J4	48
CRG	CROCKER GRADE	J110	1.97	J3	12
CRR	CARRIZO	J110	2.54	J2	18
CTW	COTTONWOOD MTN	J110	1.99	J3	12
CTWV	COTTONWOOD MTN	J101 (42)	2.52	J4	48
DB2	DOUBLE BUTTE	J110	2.80	J1	6
DBM	DOUBLE MTN	J110	2.55	J4	6
DTP	DESERT TORTOISE PK	J110	2.84	J4	6
ECF	ECHO FALLS	J110	2.01	J1	12
ELM	EL MIRAGE	J101M	2.84	J5	24
ELR	ELMORE RANCH	J101M	2.61	J1	30
ELS	ELSINORE MTN	J110	2.38	J3	6
EMS	EAST MESA	J101M	2.97	J3	24
ERP	ERNIES PLACE	J101 (34)	1.96	J4	30

Table 1. cont.

CODE	STATION NAME	DISC. TYPE	DISC. ±VOLTAGE	VCO	ATTN
EWC	EAST WIDE CANYON	J101M	2.00	J4	12
EWCE	EAST WIDE CANYON	J110	1.98	J4	30
EWCN	EAST WIDE CANYON	J110	2.02	J4	30
EWCV	EAST WIDE CANYON	J110	1.97	J4	48
FAL	FALLING SPRINGS	J110	2.56	J4	6
FIL	FILMORE	J101 (26)	2.07	J4	18
FLS	FLASH 2 PEAK	J110	2.02	J4	12
FOX	FOX AIRPORT	J101M	2.84	J4	18
FRG	FARGO CANYON	J110	2.65	J4	6
FRK	FRINK	J101M	2.92	J1	12
FTC	FORT TEJON	J110	2.38	J1	18
GAV	GLEN AVON	J101M	3.34	J1	24
GAVV	GLEN AVON	J101 (35)	1.98	J4	48
GLA	GLAMIS	J110	2.90	--	--
GLAE	GLAMIS E/W	J110	1.99	--	--
GLAN	GLAMIS N/S	J110	2.48	--	--
GRP	GRANITE PASS	J101M	2.18	J4	6
GSC	GOLDSTONE	J101M	2.71	--	-
HAY	HAYFIELD	6203	----	J4	-
HDG	HIDALGO MTN	J101M	2.79	J4	6
HOD	HODGE	J101M	2.14	J4	0
HOT	HOT SPRINGS MTN	J101M	2.81	J2	6
HYS	HAYSTACK BUTTE	J101	2.16	J1	12
IKP	INKOPAH	J101M	1.98	--	--
IND	INDIO HILLS	J101 (9)	1.71	J4	18
ING	INGRAM RANCH	J101M	2.81	J1	36
INS	INSPIRATION	J101M	2.49	J4	0
IRC	IRON CANYON	J110	1.96	--	-
IRN	IRON MTN	J110	2.42	J4	6
IRS	IRIS	J101M	2.85	J4	30
ISA	ISABELLA	J101M	2.81	--	--
ISAE	ISABELLA E/W	J110	2.52	--	--
ISAN	ISABELLA N/S	J101M	2.77	--	--
JAW	JAWBONE	J101	2.93	J4	12
JFS	JOSEPH F STATEN	J101M	2.78	J4	12
JNH	JUNIPER HILLS	J101M	2.46	J2	12
JTR	JOSHUA TREE PARK	J101M	2.78	J4	0
JUL	JULIAN	J101M	2.43	J2	6
KEE	KEEN CAMP	J101M	2.88	J4	12
KYP	KEY POINT	J101M	2.76	J1	12
LAN	LANCASTER	J110	1.97	J4	24
LAQ	LA QUINTA	J110	2.11	J4	12
LAV	LAVIC	J101M	2.87	J4	0
LED	LEAD MTN	J101M	2.82	J4	12
LEO	LEONA VALLEY	J101 (40)	2.43	J4	12
LHU	LAKE HUGHES	J110	1.98	J2	12

Table 1. cont.

CODE	STATION NAME	DISC. TYPE	DISC. ±VOLTAGE	VCO	ATTN
LJB	LOVEJOY BUTTES	J101M	2.83	J2	6
LJBE	LOVEJOY BUTTES	J101 (21)	1.98	J1	30
LJBN	LOVEJOY BUTTES	J110	1.97	J1	30
LJBV	LOVEJOY BUTTES	J110	2.45	J2	48
LLA	LLANO	J110	1.99	J4	12
LOK	LOCKWOOD	J101M	2.85	J1	18
LRM	LAUREL MTN	J101M	2.85	J3	12
LRR	LITTLE ROCK RES	J110	2.60	J1	12
LTC	LTL CHUCKWALLA MTN	J110	2.79	J1	0
LTM	LITTLE MARIA MTN	J110	2.44	J4	6
MAR	MARICOPA	J110	3.06	J4	6
MDA	MOUNT DAVIS	J101M	2.09	J4	12
MEC	MECCA HILLS	J101M	2.85	J4	6
MIR	MARTINEZ INDIAN RES	J110	2.44	J4	18
MLL	MILL CREEK	J110	1.98	J1	24
MRV	MORONGO VALLEY	J101M	2.91	J1	12
MWC	MOUNT WILSON	J110	2.85	--	--
NW2	NEW RIVER	J101M	3.65	J1	36
OLY	MOUNT OLYMPUS	6243	2.78	J4	6
ORC	ORICOPIA MTN	J101 (26)	3.65	J4	6
PAS	PASADENA	J101M	2.97	--	--
PASE	PASADENA E/W	J101M	3.12	--	--
PCF	POMONA	J101M	2.90	J1	36
PEM	PINE MTN	J101M	2.93	J4	18
PEMV	PINE MTN	J101M	2.43	J4	48
PKM	PEAK MTN	J101 (21)	2.48	J3	6
PLE	PLEITO HILLS	J110	1.97	J4	18
PLT	PILOT KNOB	J101M	2.94	J1	6
PLM	PALOMAR	J110	2.02	--	--
PNM	PINTO MTN	J110	1.96	J4	12
POB	POLLY BUTTE	J110	1.98	J4	12
POBV	POLLY BUTTE	J110	2.01	J4	48
PSP	PALM SPRINGS	J101 (28)	2.88	J3	18
PTD	POINT DUME	J101M	2.91	J2	24
PVR	PALOS VERDES	J101M	2.68	J1	30
QAL	QUAIL LAKE	J101 (30)	2.60	J4	18
RAY	RAYWOOD FLAT	J101M	2.76	J4	6
RAYV	RAYWOOD FLAT	J110	3.01	J4	48
RMR	RIMROCK	J101M	2.14	J1	12
RUN	RUTHVEN	J101M	1.93	J2	12
RVM	RIO VISTA MINE	J110	2.00	J2	6
RVS	RIVERSIDE MTNS	J110	2.05	J4	6
RYS	REYES PEAK	J101M	2.89	J1	12
SAD	SADDLE PEAK	J101M	2.81	J2	12
SBB	SADDLEBACK BUTTE	J101M	2.72	--	--
SBCC	COLSON CANYON	J110	2.00	J3	18

Table 1. cont.

CODE	STATION NAME	DISC. TYPE	DISC. ±VOLTAGE	VCO	ATTN
SBCD	CASITAS DAM	J101M	3.00	J2	18
SBK	SADDLEBACK MTN	J110	1.95	J4	18
SBLC	LA CUMBRE PEAK	J101M	2.82	J2	12
SBLG	LAGUNA PEAK	6243	4.43	J4	18
SBLP	LOMPOC	J101M	2.74	J1	18
SBSC	SANTA CRUZ IS.	J101M	2.79	J4	24
SBSM	SAN MIGUEL IS.	J101M	2.79	J4	24
SBSN	SAN NICOLAS IS.	6203	----	J4	18
SCI	SAN CLEMENTE IS.	J110	2.01	--	--
SCY	STONE CYN. RESV.	J110	2.87	--	--
SDW	SIDEWINDER MINE	J101M	2.88	J5	24
SGL	SIGNAL MTN	J101M	2.83	J2	6
SHH	SHEEP HOLE MTN	J101M	2.79	J4	6
SIL	SILVER PEAK	J101M	2.33	J2	6
SILV	SILVER PEAK	J101M	3.02	J4	48
SIP	SIMI PEAK	J110	1.99	J4	12
SLT	SALTON SEA TESTBASE	J110	2.57	J2	24
SME	SANTA ROSA MINE	J101M	2.88	J2	12
SMO	SANTA ROSA MTN	J101M	2.82	J2	12
SND	SAND CANYON	J101M	2.97	J4	12
SNR	SCHAFFNER RANCH	J101M	2.78	J4	36
SNRE	SCHAFFNER RANCH	J101 (21)	1.97	J4	36
SNS	SAN ONOFRE	J101 (39)	2.00	--	-
SPM	SHIP MTN	J110	1.97	J4	0
SRT	SNORT	J110	1.96	J4	12
SS2	SAN SEVAINE	J110	1.84	J1	18
STT	SCOTT RANCH	J101 (34)	1.88	J4	18
SUN	SUNSET PEAK	J110	2.00	J3	18
SUP	SUPERSTITION MTN	J101M	2.93	J2	6
SYP	SAN YNEZ PEAK	J101M	2.85	--	-
SYS	SAN YSIDRO	J101M	2.91	J4	6
TEJ	EL TEJON	J101M	2.80	J4	12
THC	TEHACHAPI MICROWAVE	J101 (40)	2.50	J4	18
TJR	TEJON RANCH	J101M	3.00	J1	6
TMB	TEMBLOR RANGE	J101M	2.87	J1	24
TOW	TOWER 1	J101M	2.83	J4	24
TPO	TROPICO HILL	J101M	2.96	J3	6
TTM	TURTLE MOUNTAIN	J101M	2.86	J4	6
VG2	VISTA GRANDE	J110	2.02	J1	18
WAS	ALTA SIERRA	J110	1.99	J4	12
WBM	BOWMAN ROAD	J101M	2.79	J4	12
WBS	BIRD SPRING	J101M	2.85	J3	12
WCH	CHIMNEY PEAK	J101 (80)	2.50	J4	12
WCPN	CACTUS PEAK	J110	1.67	J3	0
WCS	COSO HOT SPRINGS	J110	2.36	J3	6
WCX	CHINA LAKE	J101M	2.86	J3	6

Table 1. cont.

CODE	STATION NAME	DISC. TYPE	DISC. ±VOLTAGE	VCO	ATTN
WHF	HANNING FLAT	J110	3.36	J3	12
WHS	HAIWEE SPRINGS	J110	1.95	J3	6
WHV	HAVILAH	J101M	3.01	J4	12
WIS	WISTER	J101M	2.97	J3	30
WJP	JOHNS PEAK	J101M	2.96	J3	12
WKT	KERN TULARE	J101M	2.99	J3	24
WLH	LITTLE HORSE	J101M	3.00	J2	12
WLK	WEIST LAKE	J101M	2.73	J2	30
WMF	McCLOUD FLAT	J101M	2.80	J4	0
WNM	NINE MILE CANYON	J110	3.38	J4	12
WOF	OAK FLAT	J101M	2.38	J4	6
WOR	ONYX RANCH	J110	1.98	J3	12
WRC	RENEGADE CANYON	J101M	2.86	J3	6
WRV	ROSE VALLEY	J110	2.87	J3	6
WSC	SHORT CANYON	J110	2.47	J3	12
WSH	SPANGLER HILLS	J101M	2.42	J4	6
WSP	WARM SPRINGS	J101 (19)	2.89	J4	12
WVP	VOLCANO PEAK	J101	2.44	J2	6
WWP	WALKER PASS	J101	1.95	J3	12
WWR	WHITEWATER	J101M	2.78	J1	18
XMS	CHRISTMAS CANYON	J110	1.99	J1	12
YAQ	YAQUI MEADOWS	J110	1.89	J4	12
YEG	YEGUAS MTN	J110	2.49	J1	12
YMD	YUMA DESERT	J101M	2.90	J2	18
YUH	YUHA DESERT	J101M	2.91	J4	6

Table 2:
Discriminator Parameters

See text for an explanation of the parameters.

Discriminator type		LTYPE	LN	F_0	B
J101M		1	0	3.0	1.00
		2	0	60.0	1.00
		2	0	60.0	1.00
J110		2	0	33.0	0.63
		2	0	33.0	0.63
6243 and 6203		2	0	31.0	0.90
		2	0	58.0	0.70
	70% level				
J101	21 Hz	2	0	33.0	1.00
		2	0	103.0	0.70
	26 Hz	2	0	41.4	1.00
		2	0	111.4	0.70
	30 Hz	2	0	48.1	1.00
		2	0	118.1	0.70
	34 Hz	2	0	54.9	1.00
		2	0	124.9	0.70

TABLE 3:
SOUTHERN CALIFORNIA EARTHQUAKES, MAG. 3.0 AND LARGER
JANUARY 1 THROUGH JUNE 30, 1986

Times are GMT. All magnitudes are M_L. A '*' next to the depth indicates that the depth was fixed. Depths are in kilometers. The CUSPID is the unique number assigned to each event by the CUSP system.

MON	DA	HRMN	SEC	LATITUDE	LONGITUDE	Q	MAG	DEPTH	CUSPID
JAN	2	2141	26.35	36 18.20	-120 20.10	C	3.0	6.0*	112518
JAN	12	0941	48.46	35 19.54	-118 31.43	A	3.2	2.8	113182
JAN	14	1312	14.03	33 54.83	-116 41.80	B	3.4	13.4	114619
JAN	17	1752	00.78	36 12.20	-120 09.75	C	3.4	6.0*	113956
JAN	18	2038	42.43	36 15.87	-120 14.44	C	3.0	6.0*	114030
JAN	21	0054	19.95	32 02.98	-116 22.10	C	3.0	6.0*	114164
JAN	22	1626	53.96	33 41.16	-119 08.02	C	3.6	6.0*	114364
JAN	28	0253	50.52	34 28.77	-120 36.56	C	3.1	10.9	114698
FEB	3	1228	09.29	32 15.04	-117 43.80	D	3.1	6.0*	115055
FEB	10	0042	03.28	32 10.42	-117 34.23	D	3.6	6.0*	115520
FEB	10	1642	14.01	36 10.26	-120 10.44	C	3.2	6.0*	115564
FEB	17	0212	33.48	34 06.94	-116 01.79	A	3.8	11.3	116008
FEB	17	1058	38.63	32 57.95	-115 33.17	A	3.4	8.5	116018
FEB	17	1346	42.42	33 33.27	-116 48.39	A	3.2	0.1	116057
FEB	17	1915	06.10	32 07.01	-114 53.47	D	3.2	6.0*	116087
FEB	18	0126	28.97	32 57.42	-115 33.25	A	3.1	5.1	116137
FEB	19	0047	24.12	32 29.11	-117 34.02	C	3.8	6.0*	117185
MAR	2	2303	01.08	35 54.60	-118 21.10	C	3.1	5.5	117349
MAR	3	1318	20.33	33 44.75	-117 31.50	C	3.3	6.0*	117447
MAR	9	2241	42.59	34 06.80	-117 46.12	A	3.5	4.9	118374
MAR	10	1533	16.03	34 24.16	-119 48.80	A	4.0	23.9	118360
MAR	13	0837	00.66	36 17.28	-120 19.28	C	3.2	6.0*	118633
MAR	16	0145	45.22	34 08.68	-117 18.88	C	3.3	8.7	118898
MAR	16	0145	45.33	34 08.98	-117 18.79	C	3.0	5.1	119028
MAR	20	0649	40.26	33 47.66	-118 18.59	A	3.3	10.1	119395
APR	5	0650	40.37	33 43.79	-118 00.60	A	3.9	13.6	121108
APR	5	1721	49.52	33 20.19	-115 42.55	A	3.7	3.1	121045
APR	21	0635	59.44	35 50.07	-117 45.95	A	3.3	3.7	122406
APR	24	0201	48.74	32 26.64	-115 15.28	C	3.2	6.0*	122743
APR	24	0231	23.98	32 27.98	-115 15.92	B	3.3	15.9	122746
APR	25	1909	27.05	33 28.70	-115 38.96	A	3.0	0.6	122912
MAY	1	0108	49.66	35 54.78	-117 15.87	A	3.0	0.0	123327
MAY	5	1551	04.28	35 02.68	-118 56.68	C	3.3	6.0*	123747
MAY	5	1551	44.36	35 02.85	-118 56.86	C	3.2	6.0*	123653
MAY	7	1234	09.02	34 11.75	-117 03.66	C	3.0	11.6	123849

Table 3 (continued):

MON	DA	HRMN	SEC	LATITUDE	LONGITUDE	Q	MAG	DEPTH	CUSPID
MAY	9	2316	46.14	32 24.62	-118 13.25	D	3.2	6.0*	124061
MAY	11	1731	57.10	32 05.97	-115 37.64	C	3.2	6.0*	124216
MAY	13	1129	31.21	35 15.09	-117 19.93	C	3.5	6.0*	124339
MAY	19	0412	53.31	33 53.53	-118 23.24	A	3.1	10.5	124753
MAY	23	1141	55.07	35 48.34	-118 01.15	A	3.9	10.0	125030
MAY	24	0856	29.46	35 15.62	-118 35.08	C	3.2	5.9	125199
MAY	31	0142	40.10	34 06.30	-116 36.67	A	3.5	10.1	125748
JUN	3	1414	49.27	33 47.31	-116 20.64	A	3.7	10.5	125717
JUN	3	2313	7.88	32 11.77	-115 03.82	C	3.0	6.0*	125986
JUN	10	1030	0.22	36 26.09	-120 27.26	C	3.0	6.0*	125338
JUN	13	1325	15.42	36 03.62	-119 56.26	C	3.6	6.0*	126516
JUN	18	1413	26.39	33 56.12	-116 44.53	A	3.4	17.5	700051
JUN	23	2346	8.12	32 08.56	-115 09.09	C	3.7	6.0*	700278
JUN	24	0544	32.43	32 08.35	-115 09.71	C	3.0	6.0*	126902
JUN	24	1309	59.46	32 07.45	-115 10.32	C	3.3	6.0*	700297
JUN	24	1313	1.12	32 04.84	-115 06.38	C	3.5	6.0*	700298
JUN	26	0539	47.83	33 52.15	-118 27.03	C	3.4	7.2	700391
JUN	26	1742	23.62	32 09.65	-115 06.78	C	3.0	6.0*	700414
JUN	29	1052	11.81	32 09.98	-115 07.18	D	3.1	6.0*	700514

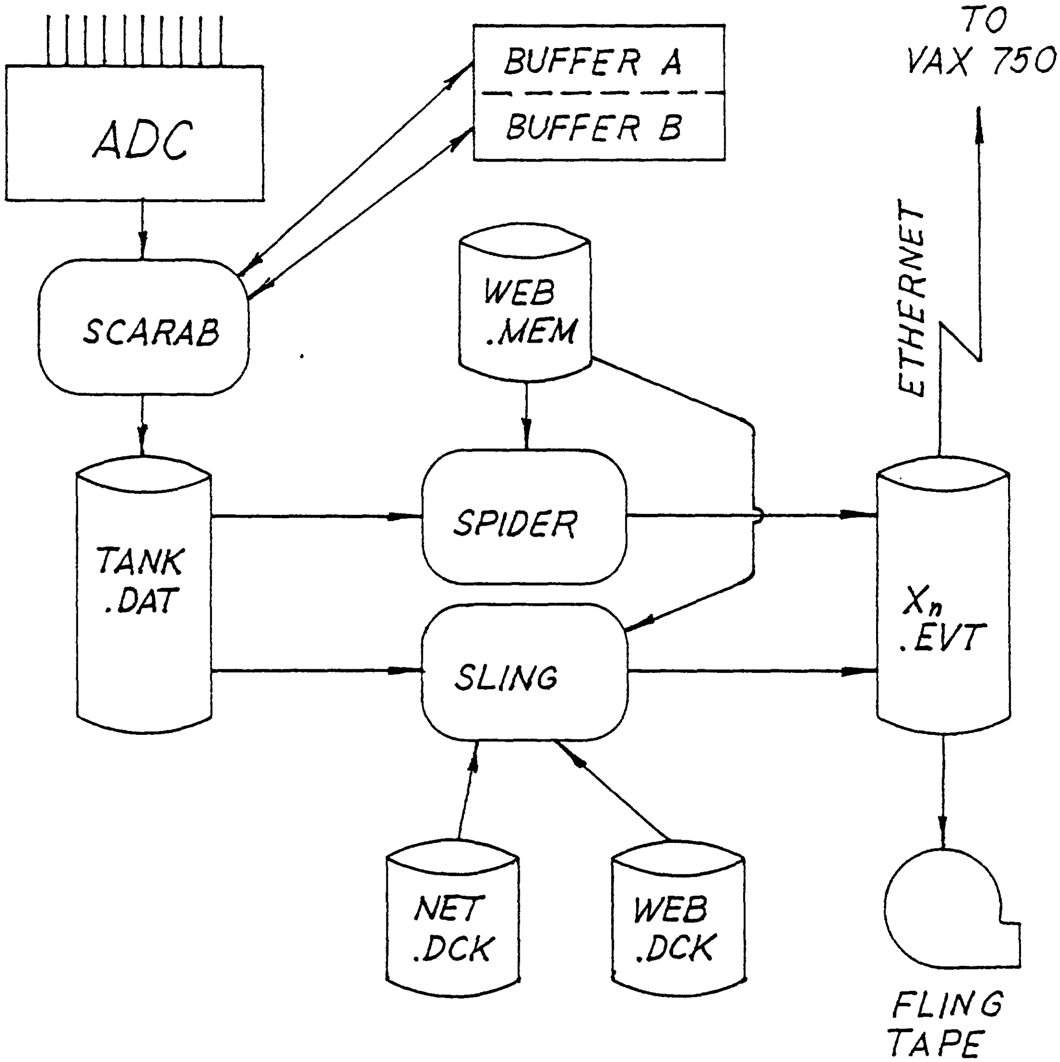


Figure 1. Flow chart of the new on-line processing system. Arrows indcate flow of data from the A/D converter (ADC) through various program modules to the final Xn.EVT disk file. See text for detailed explanation.

SOUTHERN CALIFORNIA NETWORK STATIONS, 1986

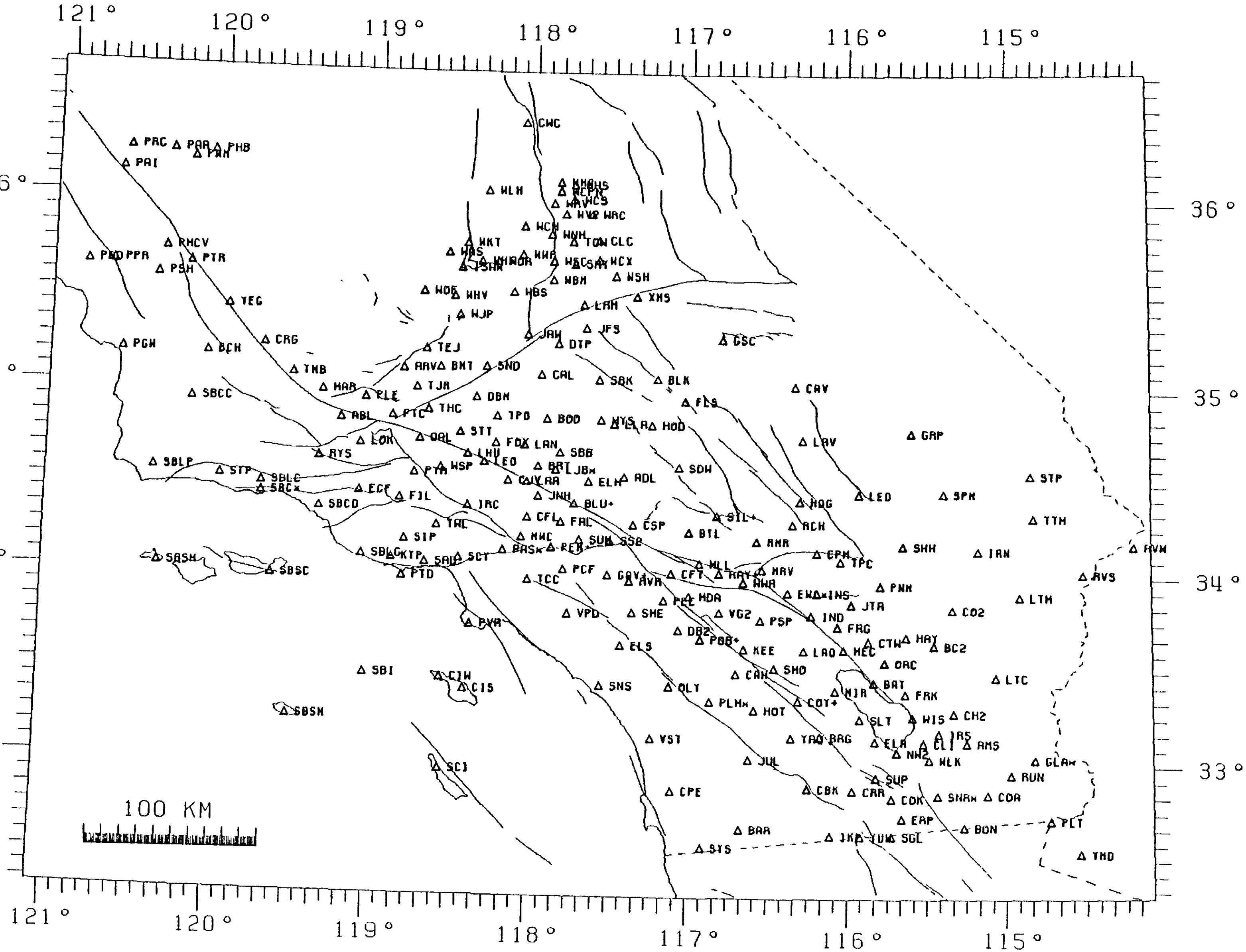


Figure 2. Current configuration of the Southern California Seismic Network.

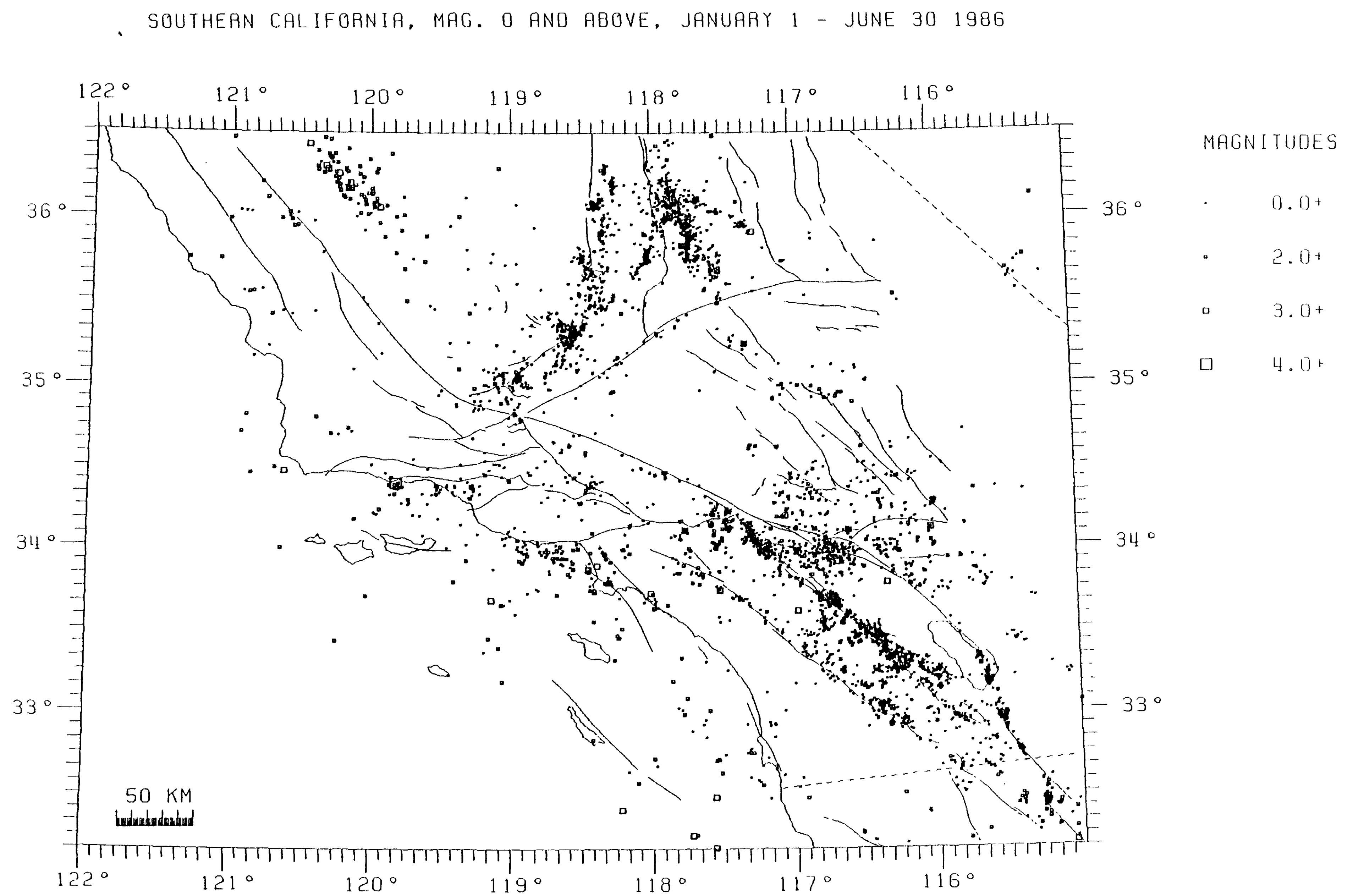


Figure 3. Epicenters of all earthquakes located by the Southern California Seismic Network from January through June, 1986.

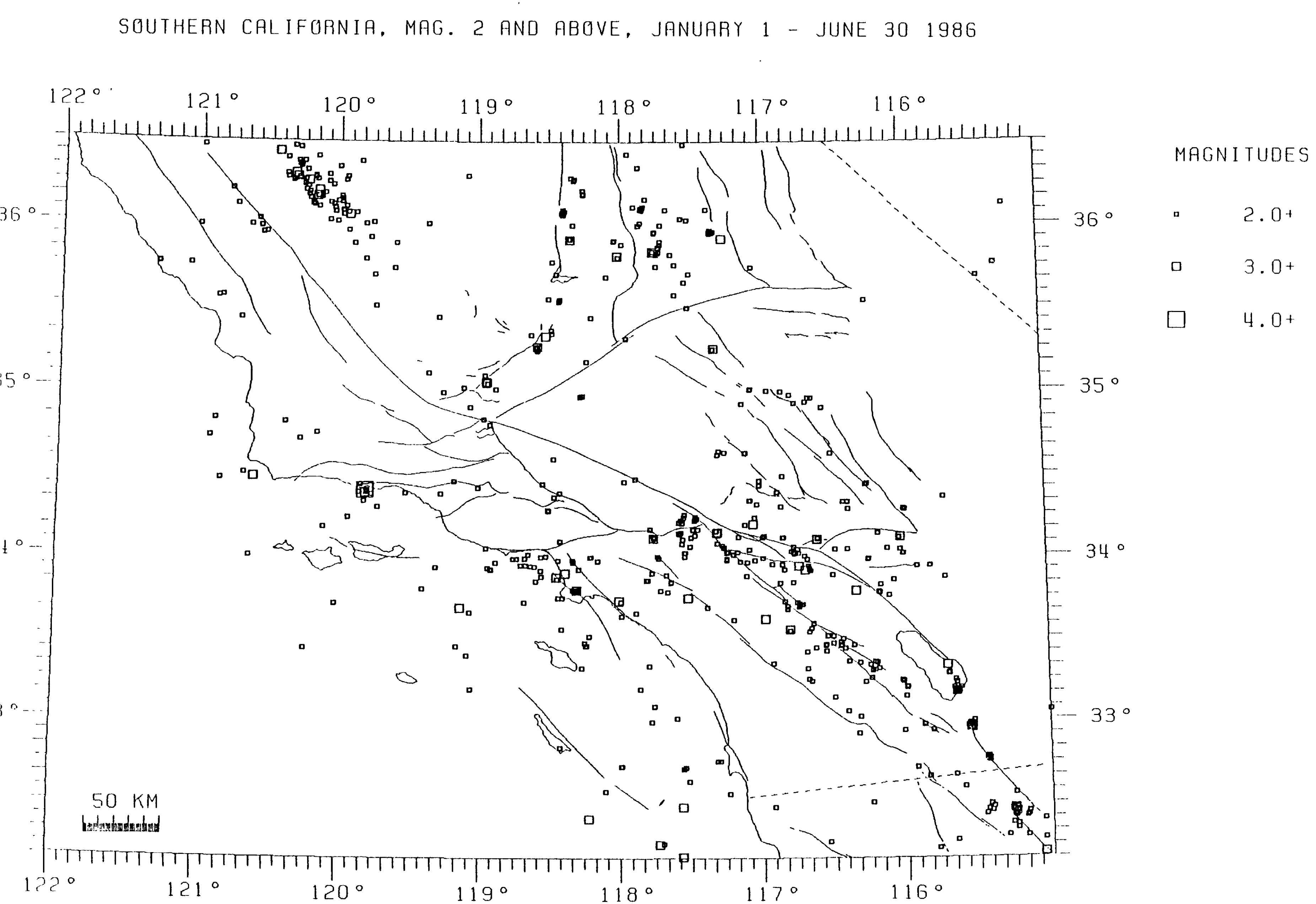


Figure 4. Epicenters of all earthquakes of magnitude greater than or equal to 2.0 located by the Southern California Seismic Network from January through June, 1986.

MAP OF REGIONS FOR SEISMICITY RATES

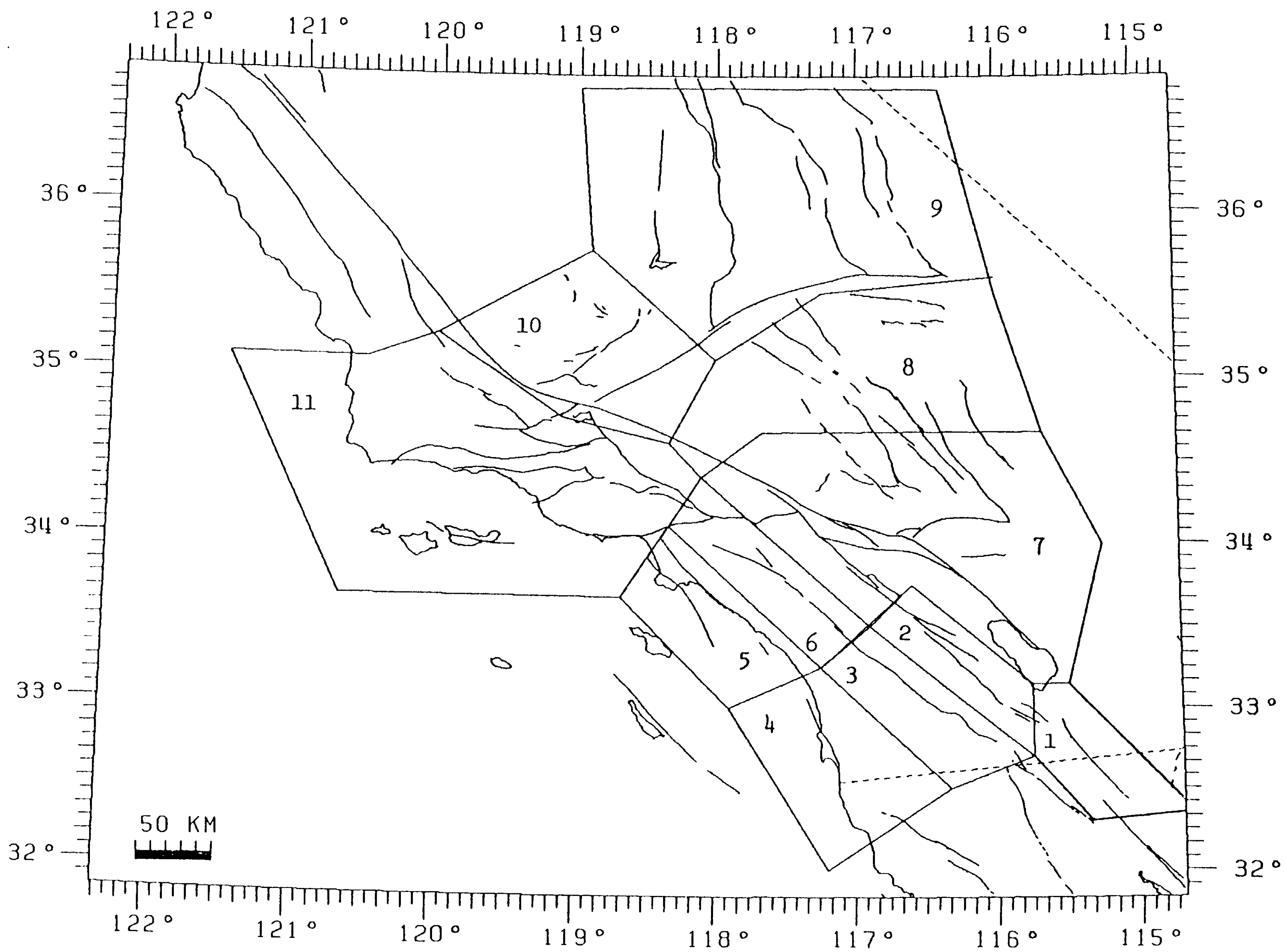


Figure 5. Subregions used for cumulative number plots in Figures 6a and 6b.

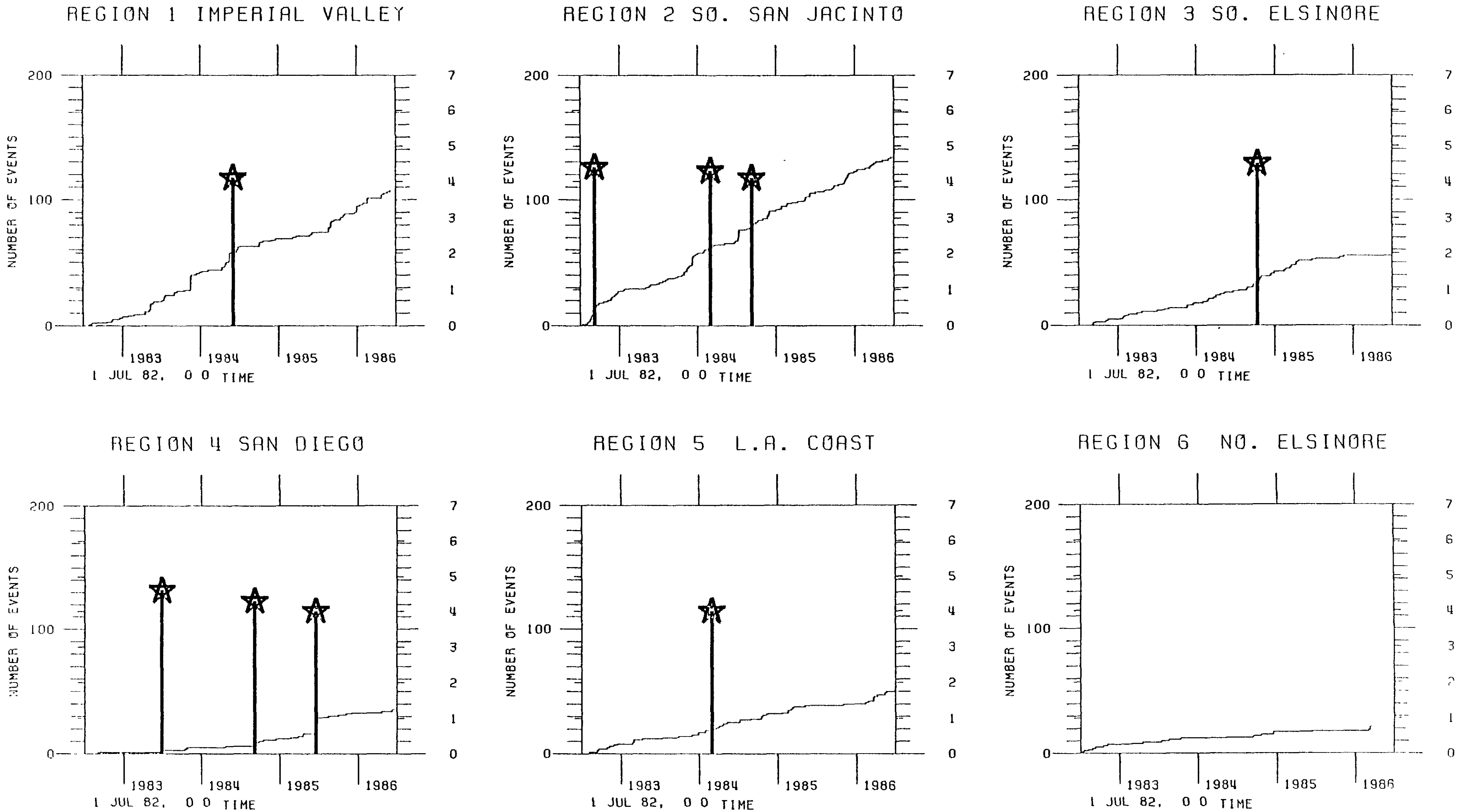


Figure 6a. Cumulative number of events in subregions 1 though 6 over the four year period ending on June 30, 1986. Sub-regions are shown in Figure 5. Only events of magnitude 2.5 or larger are used to insure homogeneous sampling over the period. The starred vertical lines mark earthquakes of magnitude 4.0 or greater (magnitude scale at right).

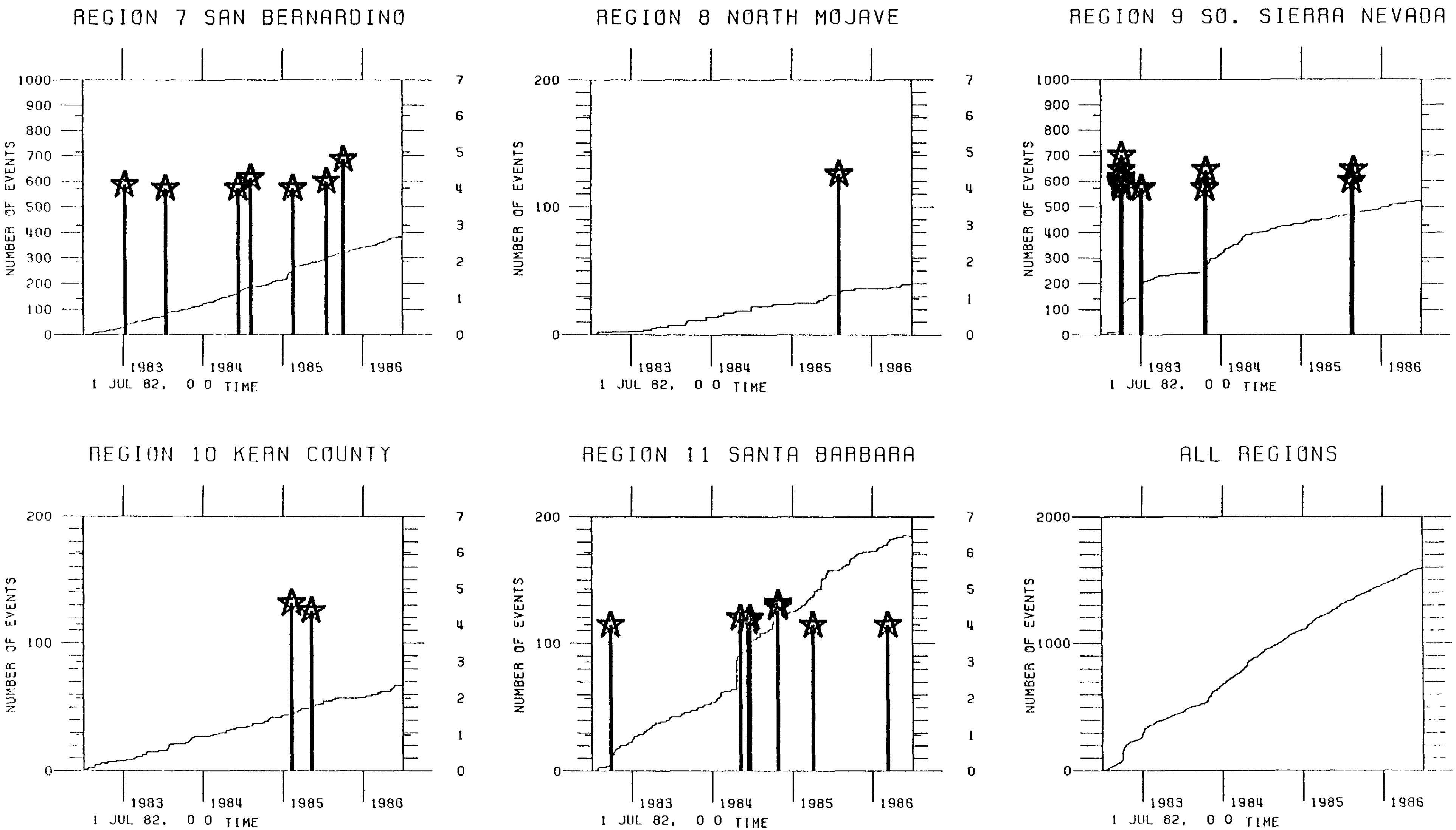


Figure 6b. Cumulative number of events in sub-regions 7 through 11 over the four year period ending on June 30, 1986. Sub-regions are shown in Figure 5. Only events of magnitude 2.5 or larger are used to insure homogeneous sampling over the period. The starred vertical lines mark earthquakes of magnitude 4.0

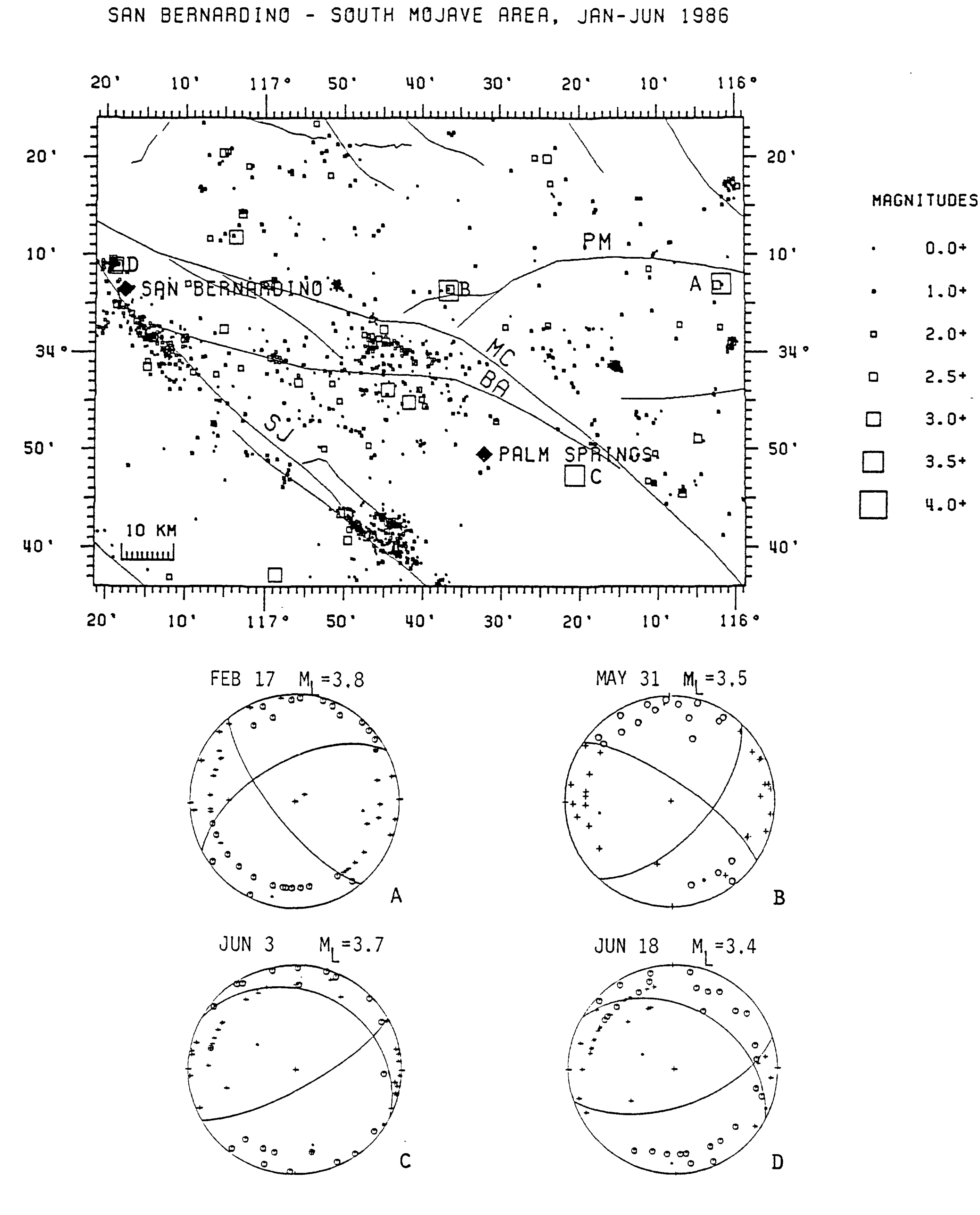


Figure 7. Events in the San Bernardino area. Single letters indicate the locations of the events for which focal mechanisms are shown. Mechanisms are lower hemisphere projections. PM, Pinto Mountain fault; MC, Mission Creek fault; BA, Banning fault; SJ, San Jacinto fault.

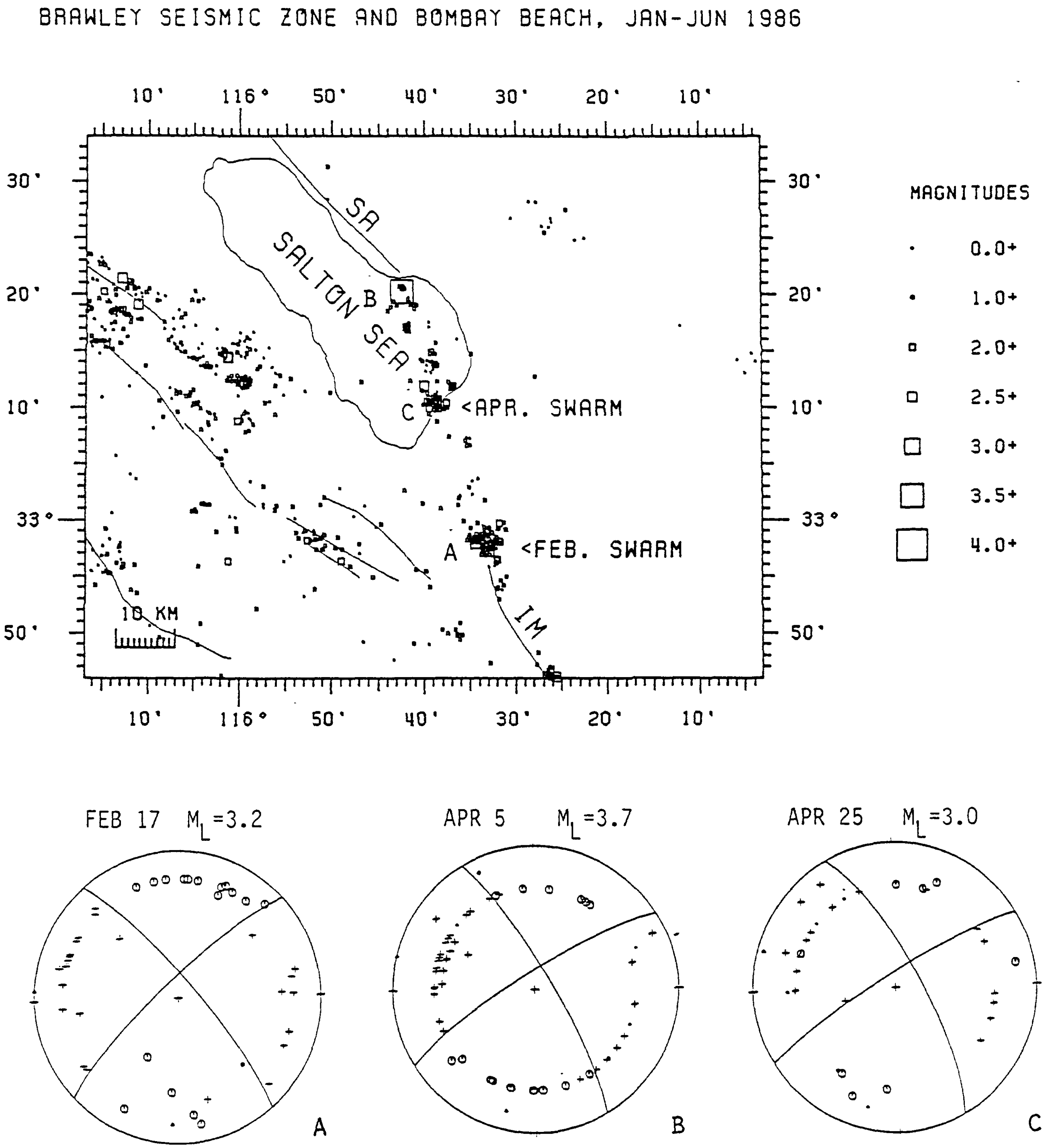


Figure 8. Events in the Salton Sea area. Locations of two swarms in the Brawley seismic zone are shown. Mechanisms are shown for a magnitude 3.7 event that occurred on April 5 and for the largest member of each swarm. Mechanisms are lower hemisphere projections. SA, San Andreas fault; IM, Imperial fault.

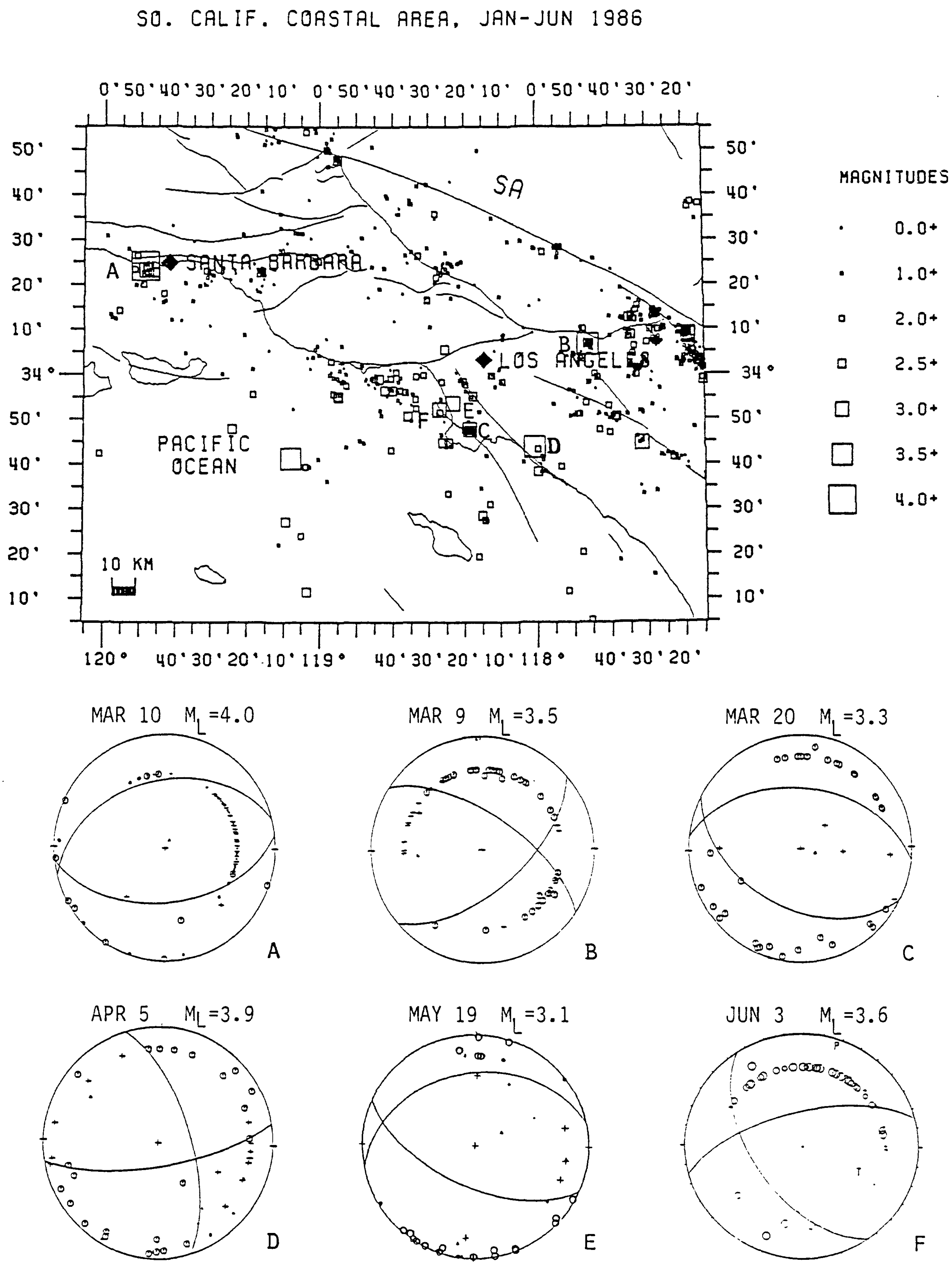
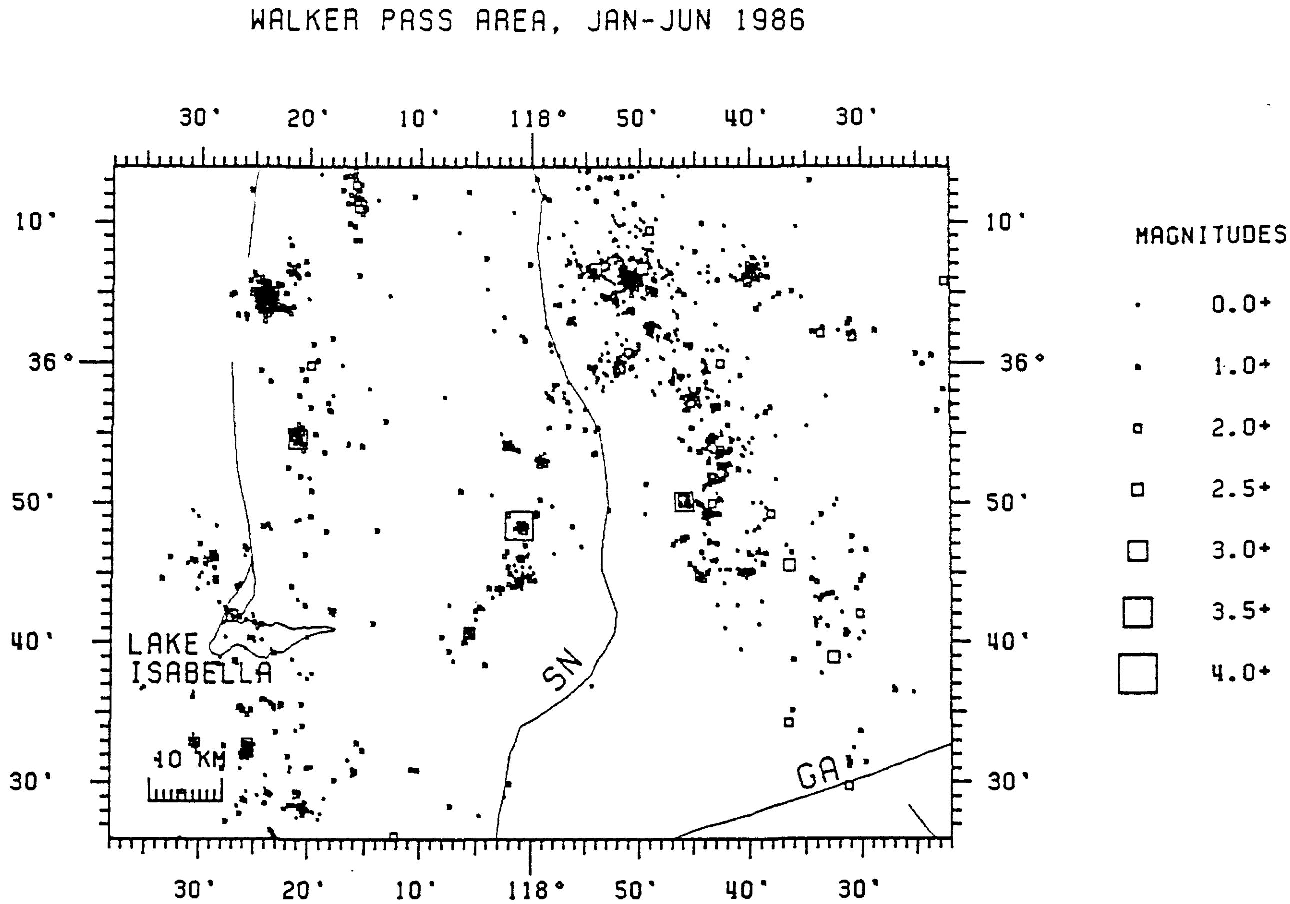


Figure 9. Events in the Los Angeles coastal area. Letters indicate the locations of the events for which focal mechanisms are shown. Mechanisms are lower hemisphere projections. SA, San Andreas fault zone.



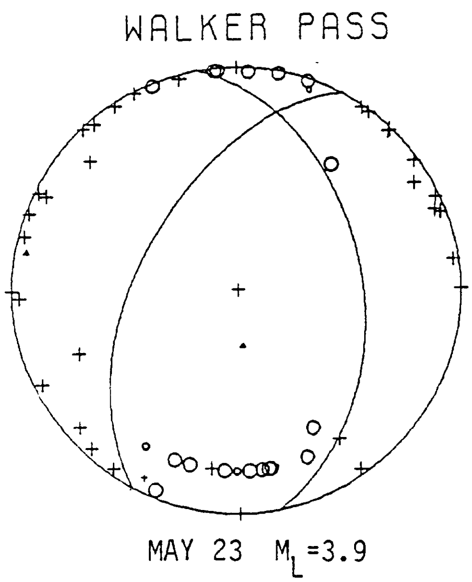


Figure 10. Events in the Walker Pass area. Focal mechanism for the magnitude 3.9 quake of May 23. Mechanism is a lower hemisphere projection. SN, Sierra Nevada frontal fault; GA, Garlock fault.