The 1998 Southern California Seismic Network Bulletin

Lisa A. Wald and David J. Wald
U.S. Geological Survey

INTRODUCTION

The Pasadena Office of the U.S. Geological Survey (USGS), together with the Caltech Seismological Laboratory, operates a network of more than 350 remote seismometers in southern California called the Southern California Seismic Network (SCSN). 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, add new stations, and develop real-time and event-tracking capabilities. Signals from the SCSN sites are telemetered to a central processing location at the Caltech Seismological 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 344,000 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 future 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.

NEW STATIONS

All but one of the new seismic stations added to the Network in 1998 are digital. The list of sixteen new digital and analog stations added through December 31, 1998 is in Table 1.

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Notes: An 'A' next to a station code indicates an analog site.
TABLE 2
Discontinued Stations in the SCSN in 1998

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<th>Code</th>
<th>Site Name</th>
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A Figure 1. Southern California Seismographic Network, January 1999. Triangles represent digital stations. Circles are analog stations.

list of all currently operating stations may be found at http://www.trinet.org/stalist.web. Figure 1 shows the locations of all the current SCSN analog and digital stations. The "ST2" type instruments are Streckheisen STS-2 broadband seismometers with an FBA-23 in addition, and the "SQW" type instruments are Guralp CMG-40T instruments with an FBA-23.

DISCONTINUED STATIONS
Six stations were discontinued in 1998. The removal dates are shown in Table 2. Most were removed because they were replaced with digital instruments at a nearby site.

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 located but have not yet run the gauntlet of quality checking, adjustment, and checking of magnitudes, and rearchiving necessary to become final (F with shading). For months marked PNK (pinked), large events (−M3.0) have been crudely rimed on only a few stations, while smaller events are absent. The event information was recorded on pink index cards, thus they are called "pinked" until the data have been located completely and checked for quality. The 1977 and 1979 events occurred before the current seismic processing system...
TABLE 3.
Processing Status of Network Data

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F: Final; P: Preliminary; PNK: Pinked

was in place, and these data are still in the process of being hand-entered into the computer. The early-1980's gaps exist because of the abundant Mammoth events during that time. When a large number of events occur in a short period of time, the seismic analysts cannot keep up with the processing, and often the event files have to be loaded onto a backup system to make room for more events to be filed on the online system. Reloading those files back onto the online system at a later time is then required for the analysis and processing. 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. Several months in 1992–1994 (from the Joshua Tree/Landers sequence) and 1996 (from the Northridge sequence) (marked P) are nearly finalized and need only magnitude calibrations. 1983 data are presently being processed.

1998 SEISMICITY HIGHLIGHTS

A total of 11,781 earthquakes and 1,642 blasts were cataloged for 1998 (Figure 2). Of the cataloged events, 166 were greater than or equal to \( M \geq 3.0 \) (Appendix A). The largest earthquake within the SCSN network in 1998 had a magnitude of 5.2 and is called the Coso earthquake. Focal mechanisms for some selected events (\( M \geq 4.0 \)) are shown in Figure 3.

For the following discussion, southern California has been divided into eleven subregions (Figure 4). These regions are arbitrary but useful for discussing the characteristics of the seismicity in a manageable context. Figure 5 sum-

406 Seismological Research Letters Volume 70, Number 4 July/August 1999
A Figure 2. All located earthquakes in southern California for the period January–December 1998.

A Figure 3. Lower hemisphere focal mechanisms for selected $\mathbf{M}_\text{L} \geq 0$ events for the period January–December 1998. Event numbers correspond to numbers in F column of Appendix A. Some focal mechanism locations have been adjusted slightly in order for each one to be seen.
A Figure 4. 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 = San Fernando/Santa Barbara.

...marizes the activity of each subregion over the past ten years. A separate discussion section follows for those regions with notable activity. The earthquakes included in the discussion are shown on Figure 6. Earthquakes of M3.5 or greater, or those of any size that were felt, are discussed. The discussions include all earthquakes recorded by the SCSN that occur between latitudes 32.0°N and 36.5°N and longitudes 114°W and 122°W. We also mention some interesting and/or large events near but outside this region; these are typically events in the Owens Valley (north of Coso) or to the south in Mexico. The dates are all based on Greenwich Mean Time (GMT).

Imperial Valley — Region 1.
This region of frequent swarms stayed true to form in 1998. A swarm began on December 1, 1997 with an M4.1 near Obsidian Butte in the Brawley Seismic Zone and continued throughout most of January. An M3.8 on January 12 was the second largest event of the swarm. The Obsidian Butte area then stayed relatively quiet until an M3.8 occurred on November 2. Near Ocotillo, at the U.S./Mexico border, there was an M3.5 on January 26 and an M3.7 on December 12. Another small swarm occurred near El Centro in October. The rest of the seismic activity down south actually occurred in Mexico but may have been felt by residents along the border. On August 2, there were an M3.3 and an M3.7 44 miles south of the border town of Calexico. Then an M3.8 in the Cerro Prieto Seismic Zone shook the area 26 miles south-southeast of Calexico on October 14. A few days later a swarm began 50 miles south of Calexico that included two M3.7's, an M3.6, an M4.2, an M3.9, and an M3.8 within three days. This was followed two weeks later by an M4.0 40 km to the south.

South San Jacinto — Region 2.
The only events of interest in this area were an M3.9 near Salton City on June 26 in the aftershock zone of the Superstition Hills earthquake, although after this long it is no longer considered an aftershock, and an M4.1 (Figure 3, #5) on July 10 in the Anza-Borrego desert 6 miles from Ocotillo Wells. The latter event was in the San Jacinto Fault system and was felt as far as San Diego and Palm Springs.

South Elsinore — Region 3.
It was relatively quiet in this area except for an M3.7 on June 4 just north of Mt. Palomar Observatory, which was felt in Temecula and Pauma Valley, and an M3.9 on July 24 near Julian, close to the Elsinore Fault Zone.
Figure 5. Cumulative number of events \((M_\text{L} \geq 2.5)\) in all subregions over the ten-year period ending December 1998. The boundaries of the subregions are shown in Figure 4. Vertical bars represent time and magnitude (scale on right) of large events \((M_\text{L} \geq 4.0)\). Note that the vertical scales of the plots may not be the same.
San Diego — Region 4.
An M4.8 180 miles offshore southwest of San Diego on July 9 was recorded just outside this region.

Los Angeles — Region 5.
The largest event in the Los Angeles area in 1998 was an M3.8 on April 25 north of downtown in Alhambra that was widely felt throughout Los Angeles. Ten days before that, an M3.2 just slightly to the south but north of downtown in Silver Lake was also widely felt. Since the metropolitan area is so densely populated, even small earthquakes are often felt. On June 14 an M2.7 and on July 20 an M2.5 were both felt in Newport Beach; these occurred in the Newport-Inglewood Fault Zone. On the northern section of the Newport-Inglewood Fault Zone, an M2.5 was felt under Inglewood on December 13. The Santa Monica Beach area felt an M2.8 under Culver City on August 26, and an M2.5 under Encino shook residents on November 11. This one fell just outside the Northridge (January 17, 1994) aftershock zone. Offshore events included an M3.7 30 miles south-southwest of Dana Point on June 14, and further to the north an M3.6 38 miles south of San Clemente Island on November 10.

North Elsinore — Region 6.
An M4.3 (Figure 3, #1) on January 5 in Chino was widely felt from Santa Monica to San Bernardino. This event had a strike-slip mechanism and a location consistent with the Whittier Fault. Aftershocks continued for about one week. Two days later on the other side of the Chino Hills in Brea an M3.1 was felt. Later in the year on June 5 Orange County felt an M2.7 near Fullerton.

San Bernardino/South Mojave—Region 7.
Landers aftershocks (June 28, 1992) continued sporadically throughout the year, including an M3.6 near Lucerne Valley on April 17, an M3.6 nearby on July 4, an M3.6 on July 27 near Desert Hot Springs in the Joshua Tree aftershock zone, and an M3.5 near Yucca Valley on November 10. The Big Bear area had a little excitement with an M4.7 (Figure 3, #6) on August 16 near Mc. San Gorgonio. The earthquake had a strike-slip mechanism, and the aftershock pattern defined a northwest-trending fault. Another event of M4.7 (Figure 3, #8) occurred here on October 1. Then in a different location 4 miles north of Big Bear City an M4.9 (Figure 3, #9) strike-slip event surprised everyone just twenty-six days later. It was
named the Whiskey Springs earthquake, and it had a healthy
aftershock sequence, including the largest aftershock of
M4.1 (Figure 3, #10) on the same day. Continuing to the
east, the Morongo Valley area had an M3.7 event on June 21
near the intersection of the Morongo Valley Fault and the
Mission Creek branch of the San Andreas. The mechanism
was oblique strike-slip, consistent with the Mission Creek
Fault. In Yucaipa an M3.4 was felt on August 23. An M4.5
(Figure 3, #4) in the Crafton Hills near Redlands on March
11 shook people in the Inland Empire and as far away as
Thousand Oaks and Palm Springs. This location is near the
intersection of the San Jacinto Fault and the Crafton Hills
Fault, and the normal faulting mechanism indicates it was on the
Crafton Hills Fault. Late Arrowhead experienced an
M3.5 with a normal mechanism on August 17. An M4.4
(Figure 3, #7) shook the Wtighrwood area on August 20
and was widely felt in the Inland Empire. Although it was close
to the San Andreas Fault, it had a thrust mechanism.

The San Bernardino area had its share of seismicity, too.
February 3 saw an M3.5 in the San Bernardino Mountains,
and another M3.5 occurred much later in the year on
December 12 near Cabazon in the foothills. Closer to the
more highly populated area, an M3.0 was felt near Rialto on
May 22, and an M2.7 was felt by a few near Rancho
Cucamonga on September 30.

Further south a small swarm buzzed on December 18 at
Bombay Beach on the northeast shore of the Salton Sea.

North Mojave—Region 8.
There was a lone M3.6 thrust went 11 miles south of Boron
on August 12.

South Sierra Nevada — Region 9.
The largest earthquake in southern California occurred in
this region on March 6. It was an M5.2 (Figure 3, #2) and
was called the Coso earthquake, since it was located near the
Coso geothermal area, 2 km west of an M5.3 that occurred
on Thanksgiving of 1996. An M5.0 (Figure 3, #3) followed
the next day, and an M3.8 occurred later on March 18. Even
though this is an extensional regime, these events were strike-
slip. They were felt in China Lake and Ridgecrest. On May
10 an M3.5 occurred in the Coso Range near Coso Junction,
10 miles from the March activity. An M3.9 initiated a small
swarm just east of Coso Junction on June 8.

Kern County — Region 10.
There was an M3.6 in the mountains 16 miles north-north
west of Tehachapi on December 11.

San Fernando/Santa Barbara — Region 11.
Offshore there were an M3.5 on July 17, 18 miles southeast
of Santa Cruz Island, and an M3.721 miles south-southwest
of Pt. Arguello (63 miles west of Santa Barbara) on December
11. An M3.9 occurred on December 18 offshore north of
Santa Barbara Island, and two days later an M3.7, pre-
ceded two minutes earlier by an M3.2, shook the offshore
area southwest of Laguna Beach. On January 11, an M3.3
under Van Nuys was widely felt in the San Fernando Valley
and the Hollywood area. June 3 brought an M3.0 near
Encino in the southern San Fernando Valley, just outside of
the Northridge aftershock zone, that was felt in the epicen-
tral area. Northridge aftershocks were felt occasionally
throughout the year. On January 4, an M3.3 was felt as part of
a cluster of aftershocks near Canoga Park in the western
San Fernando Valley. Later in the month on January 30 an
M3.0 was felt in the Granada Hills area. An M3.7 was felt in
Simi Valley and the western San Fernando Valley on May 1.
An M3.9 near Chatsworth was widely felt on June 17, and an
M3.3 occurred under San Fernando on August 26.

WEB NOTES

Did You Feel It?
Did you feel it? If you did, or even if you didn't, you can
report what you felt on the Southern California Community
Internet Intensity Map Web page. Automatic, rapid gener-
ation of seismic intensity maps is accomplished by collecting
shaking and damage reports from Internet users immediately
following felt earthquakes in southern California (Quitor-
iano et al., 1998). Intensity survey questionnaires are made
available through the World Wide Web within minutes
after the detection of a significant event by the TriNet
real-time system. Responses to the questionnaire are
automatically converted to Community Decimal Intensities (CDI)
using a modification of the algorithm from Dengler and Dewey
(1998). Distinct areas are defined by the geographic bound-
aries of 5-digit ZIP codes. As questionnaires are contributed,
the associated ZIP code is color-coded based on the calcul-
ated intensity, and a regional map of the seismic intensity
distribution is created and displayed a few minutes after each
response. Combining felt reports with automated processing
and intensity assignment allows for much more rapid
generation of preliminary intensity maps than the standard prac-
tice of mailing intensity surveys and manually processing
them. In the absence of automatic monitoring, the process
can be initiated by a certain number of felt reports. The URL
for the Community Internet Intensity Maps is http://www-
socal.wr.usgs.gov/clim.html.

Northridge Earthquake Online
A collection of work done by the U.S. Geological Survey fol-
lowing the Northridge earthquake is now online at http://
www-socal.wr.usgs.gov/north. Users can download data and
maps showing many aspects of the earthquake, such as main-
shock rupture, damage patterns, local site response effects,
and landslide effects. Also available are various supporting
data sets including a fault database, digital geologic maps,
topographic data, and reference lists to Northridge publica-
tions with links to those that are online. The site also has
photos from the earthquake and animations of the earth-
quake rupture and aftershock sequence.
FOR FURTHER INFORMATION


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REFERENCES


Earthquake Hazards Team
U.S. Geological Survey
525 South Wilson Avenue
Pasadena, CA 91106

Appendix A

Significant Southern California Earthquakes

All events of $M \geq 3.0$ for the period January to December 1998. 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 arrival times (in seconds), 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 3. Note that these events have not been finalized, and therefore their magnitudes may not be of the highest accuracy. In most cases, if the magnitude is incorrect, it is larger than indicated...