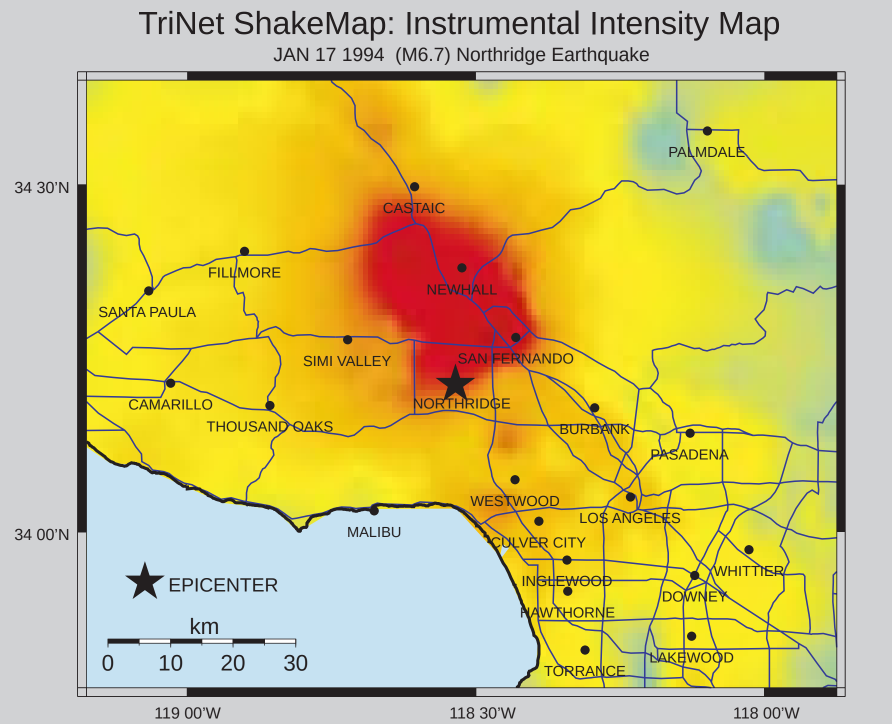
UNDERSTANDING EARTHQUAKE HAZARDS IN URBAN AREAS

"ShakeMaps"—Instant Maps of Earthquake Shaking

Immediately following an earthquake, emergency managers must quickly make response decisions using limited information. Automatically and rapidly generated computer maps of the intensity of ground shaking (ShakeMaps) are now available within 5 minutes after an earthquake in southern California. This quick, accurate, and important information can aid in making the most effective use of emergency response resources.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

The ShakeMap for the 1994 Northridge, California, earthquake shows that the greatest shaking and the most damage occurred to the north of the epicenter and in other isolated areas. The earthquake location and magnitude alone do not give that information. This capability was developed after the Northridge earthquake. However, had this been available for that earthquake, it could have been immediately used to guide emergency-response teams to areas that potentially had the greatest need.

After a damaging earthquake, emergency managers must quickly find answers to important questions: What areas have sustained the most serious damage? What areas are relatively free of damage? What resources must be mobilized and in what quantities? Government response organizations typically answer these questions through reconnaissance. Private-sector organizations must conduct their own reconnaissance and await reports from the government regarding the status of the regional infrastructure and services. Such reconnaissance requires hours and sometimes days to complete. As a result, decisions regarding search and rescue, medical emergency response, mass care and shelter, and other critical response needs must often be made while information is still incomplete.

A new way to provide such information quickly is the automatic generation of computer maps, called ShakeMaps, which portray the extent of potentially damaging shaking following an earthquake. ShakeMaps can be used for emergency response, loss estimation, and for public information through emergency response networks, the Internet, and the media. ShakeMaps have been created for earthquakes in southern California for the last several years as part of the TriNet Project, a joint research and development effort of the U.S. Geological Survey (USGS), California Institute of Technology (Caltech), and the California Division of Mines and Geology (CDMG).

In the past, the Southern California Seismic Network (SCSN), operated by the USGS and Caltech, has contributed to reconnaissance efforts after a major earthquake and has provided, within the limits of available technology, rapid information on seismic activity in the region. The information generated by the SCSN has included the magnitude, location, identification of the fault that ruptured, and some assessment of the probability of damaging aftershocks. While useful, this information has not been sufficient to support rapid post-earthquake emergency management decision-making. Because an earthquake happens over a fault surface, not at a single point, the location of the earthquake (the epicenter) tells us only where the earthquake started, but not necessarily where the shaking was the greatest. Other factors such as rupture direction and soil type influence the amount of shaking in a particular area.

With the inception of the TriNet project, following the Northridge earthquake in 1994, this situation has changed. Deployment has begun of a state-of-the-art seismic network with digital communications in real time. This network enables seismic data to be used in new and innovative ways. Advances in telecommunications and computer processing speed, and new understanding of the relation between recorded ground motions and damage intensi-

Two different ways to describe the size of an earthquake:

Magnitude

Magnitude is a number representing the total amount of energy released by the earthquake source. It is based on the amplitude of the earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Intensity

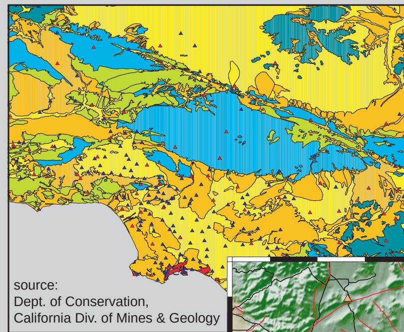
Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region, depending on the location of the observer with respect to the earthquake epicenter. In general, the intensity decreases as one moves away from the fault, but other factors such as rupture direction and soil type also influence the amount of shaking. Roman numerals are used to describe intensities to distinguish them from magnitudes. The Modified Mercalli Intensity Scale is currently used in the United States.

For example, the magnitude of the October 16, 1999, Hector Mine, California, earthquake was 7.1, and the shaking intensities ranged from IX (very strong) close to the epicenter to II-III (weak) at distances up to 500 km (300 mi) away.

How a ShakeMap Is Made

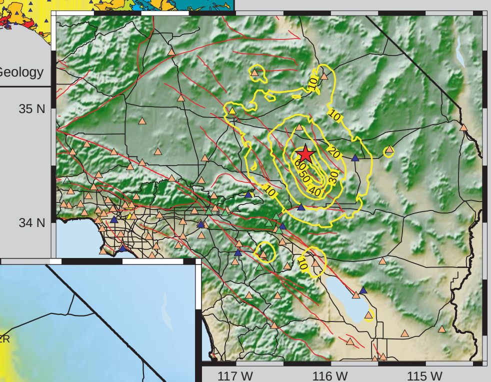
1

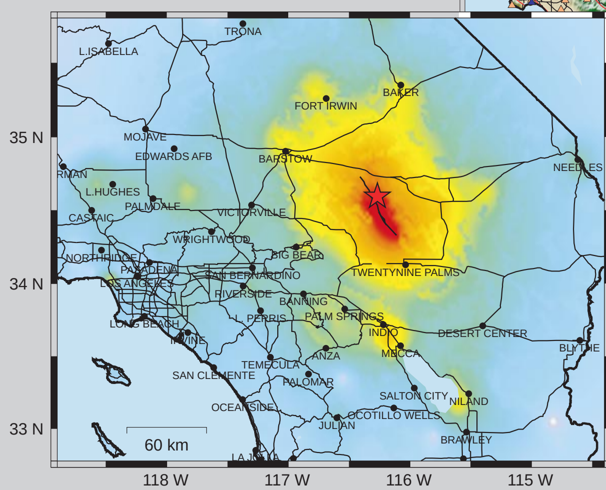
The shaking level is recorded at hundreds of seismic stations (triangles). In the areas between stations, shaking levels are estimated on the basis of knowledge of how seismic energy travels and the local geology, here color coded — the relatively weak soils are shown in orange, yellow, and red.



2

In this example of the 1999 Hector Mine, California, earthquake, amplitudes of the ground motion are contoured, indicating where recorded motions were strongest.





3

Ground motions are converted to color-coded seismic intensity to show the potential damage and the perceived shaking level at all locations.

ties have made ShakeMaps possible. These maps show the distribution of ground shaking in the region and provide information to help direct emergency-response teams to areas where there is the greatest potential need. It is the distribution of intensity (local severity of shaking), rather than the magnitude (the total energy released by the earthquake), that provides useful information about areas likely to have suffered damage.

The data used to produce the ShakeMaps are automatically collected from hundreds of seismic instruments across southern California and received at a central processing site. The shaking values are plotted on a map, and contour lines are added to show areas of strong shaking. The instrumental intensity map showing estimates of the perceived shaking and potential damage is created by converting the raw recorded ground-shaking data (acceleration and velocity) to intensities. Maps showing the distribution of maximum acceleration and of maximum velocity are also prepared. Additional maps provide information on specific frequencies of shaking waves, which indicates the probable response of different types of buildings to the ground motion. These are useful for estimating which areas are most likely to have damaged buildings. All the maps are refined and updated as more data become available.

The resulting maps are organized in a database and made available on the World Wide Web (http://www.trinet.org/shake). The website provides access not only to maps of the most recent earthquake, but also to maps of significant events in the past. The maps are interactive—selection of an individual station on the map displays detailed information, including the station name, geographic coordinates, and the local peak ground motion values.

Although some areas of heavy damage were quickly identified after both the 1994 Northridge and the 1989 Loma Prieta earthquakes in California, additional hidden pockets of severe damage were only belatedly discovered. ShakeMaps are able to expose such areas quickly so that emergency services may be directed to them. By displaying the distribution of ground shaking within 5 minutes after an earthquake, ShakeMaps enable emergency responders to quickly make decisions based on an accurate overview of the scope of the disaster.

Efforts are now underway to expand the use of ShakeMaps to other seismically active areas of the United States. Eventually it will be possible for any seismic network to make ground-shaking maps for its region available rapidly on the Internet. An investment in high-quality instrumentation and support can result in a system that will aid in more efficient emergency response and help reduce losses and save lives after an earthquake. The work of U.S. Geological Survey scientists in TriNet is only part of the ongoing USGS efforts to safeguard lives and property from future earthquakes.

For More Information

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ShakeMaps are at:
http://www.trinet.org/shake

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