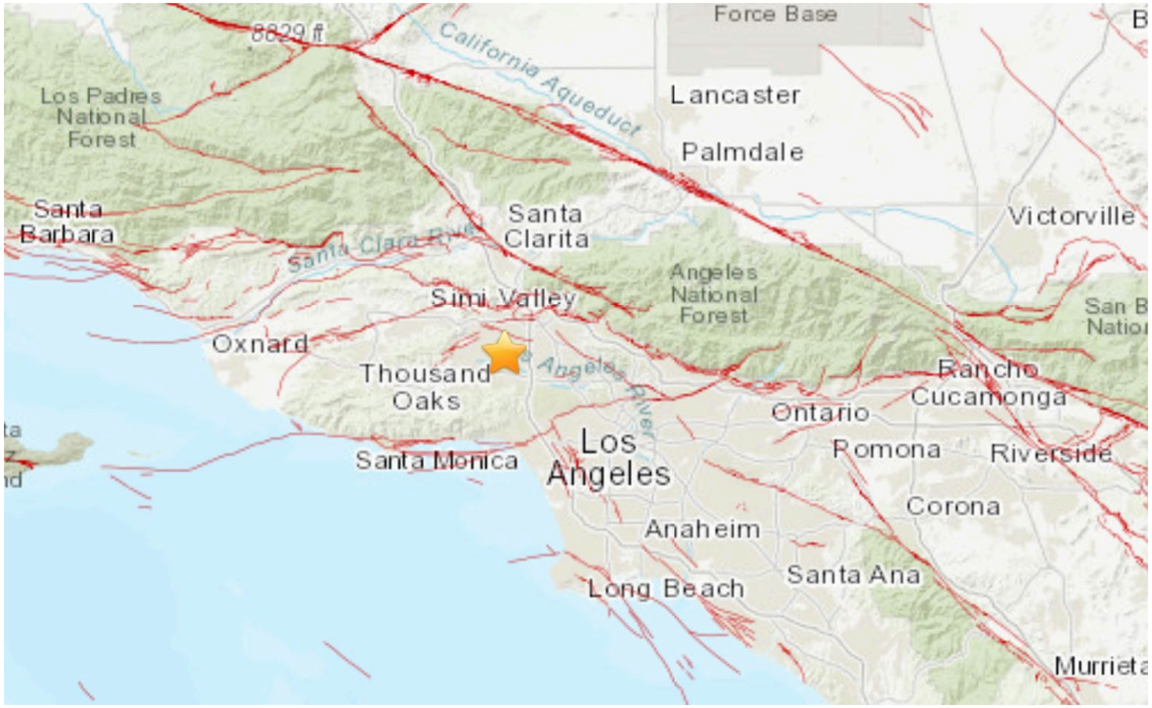
Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

Twenty-eight years ago, a magnitude 6.7 earthquake shook the San Fernando Valley north of Los Angeles in the early morning of January 17th. It destroyed homes, damaged hospitals and schools, triggered over 10,000 landslides, and caused sections of elevated freeways to collapse. 60 people lost their lives and nearly 9,000 were injured. While a M 6.7 quake is relatively moderate in size, it had a major impact because it was centered directly beneath a heavily populated and built-up urban region.

California is safer today because of this earthquake. It prompted action and legislation to protect people, homes, and led to the creation of the California Earthquake Authority (CEA) to help mitigate earthquake losses across the state.

CEA CALIFORNIA EARTHQUAKE AUTHORITY™



IRIS Teachable Moments

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The Modified-Mercalli Intensity (MMI) scale is a ten-stage scale, from I to X, that indicates the severity of ground shaking. Intensity is based on observed effects and is variable over the area affected by an earthquake. Intensity is dependent on earthquake size, depth, distance, and local conditions.

Extreme shaking was felt in the area closest to the earthquake.

MMI	Perceived Shaking
X	Extreme
IX	Violent
VIII	Severe
VII	Very Strong
VI	Strong
V	Moderate
IV	Light
II-III	Weak
I	Not Felt

Estimated shaking intensity from M 6.7 Earthquake

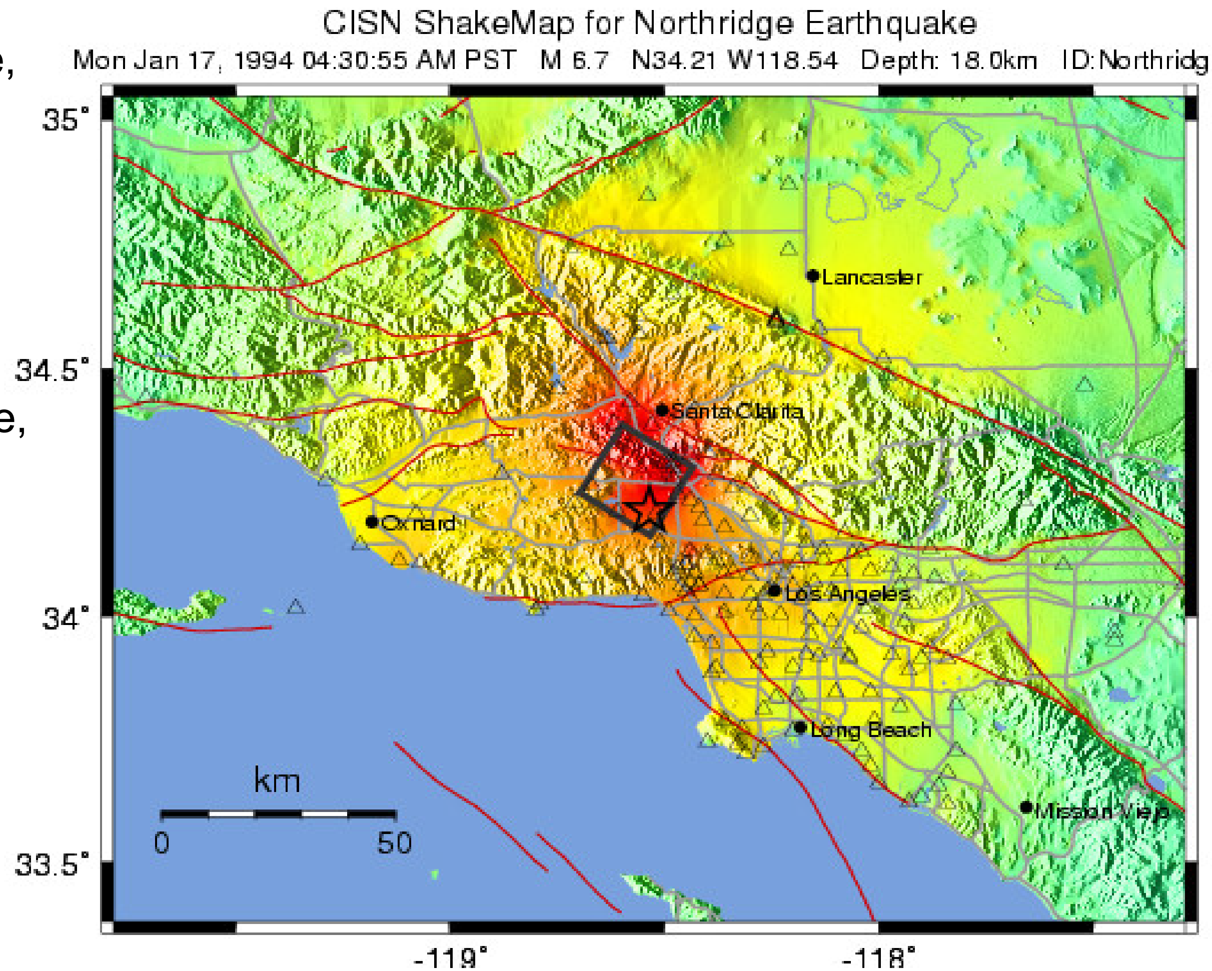
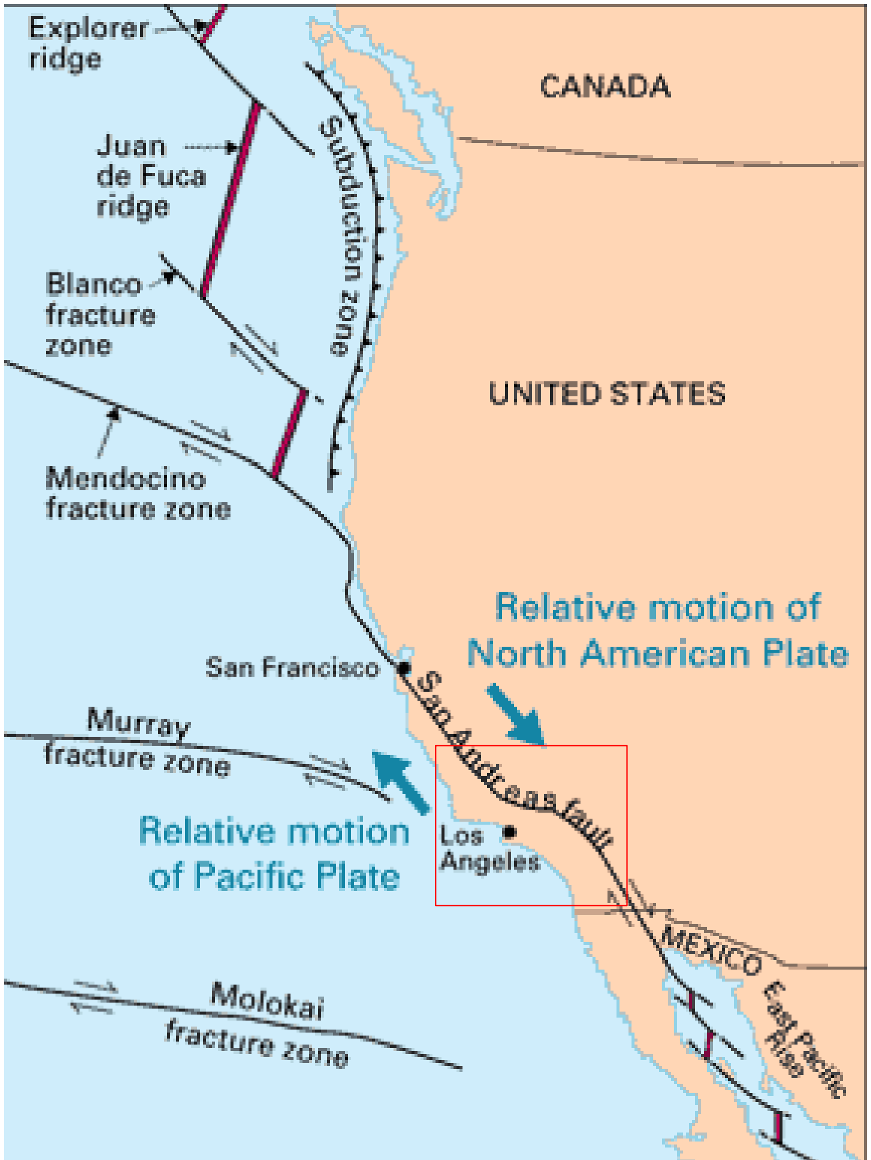


Image courtesy of the California Integrated Seismic Network

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC



The relative motion between the North American Plate and the Pacific Plate is 50 mm/yr (~ 2 inches/yr), but that rate is distributed across all the faults that are part of the San Andreas Fault Zone.

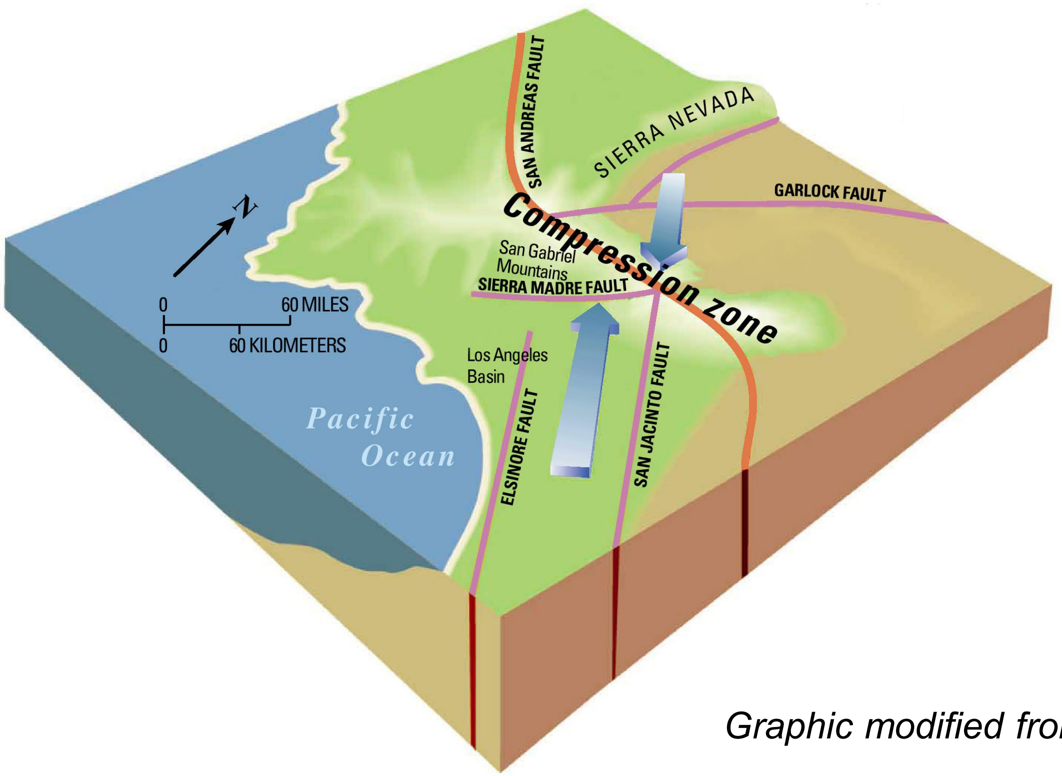
The San Andreas Fault Zone includes the San Andreas Fault plus many sub-parallel faults that together take up the motion between the two plates.

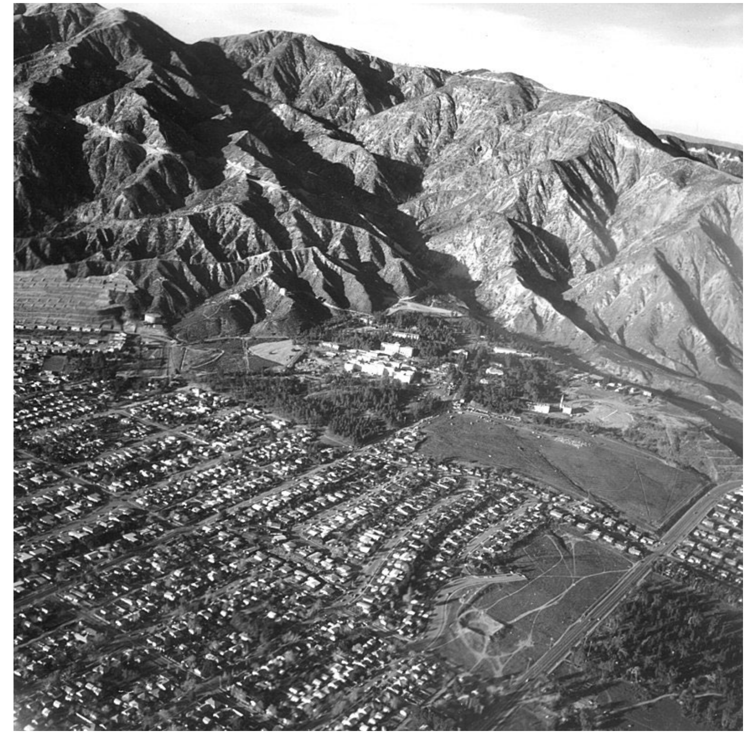
In northern California, the zone includes the Northern San Andreas, Hayward, Calaveras, as well as many other faults.

In southern California, the zone is even wider, encompassing the Southern San Andreas, the San Jacinto, and other faults. See the next slide for more detail in the Los Angeles area (red box).

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

In southern California, the San Andreas Fault Zone encompasses the Southern San Andreas, the San Jacinto, and many other faults in the Los Angeles area. The San Andreas Fault makes a bend (called the Big Bend) that creates a region of compression. This compression causes thrust faults and folds creating uplift that has formed the San Gabriel Mountains.





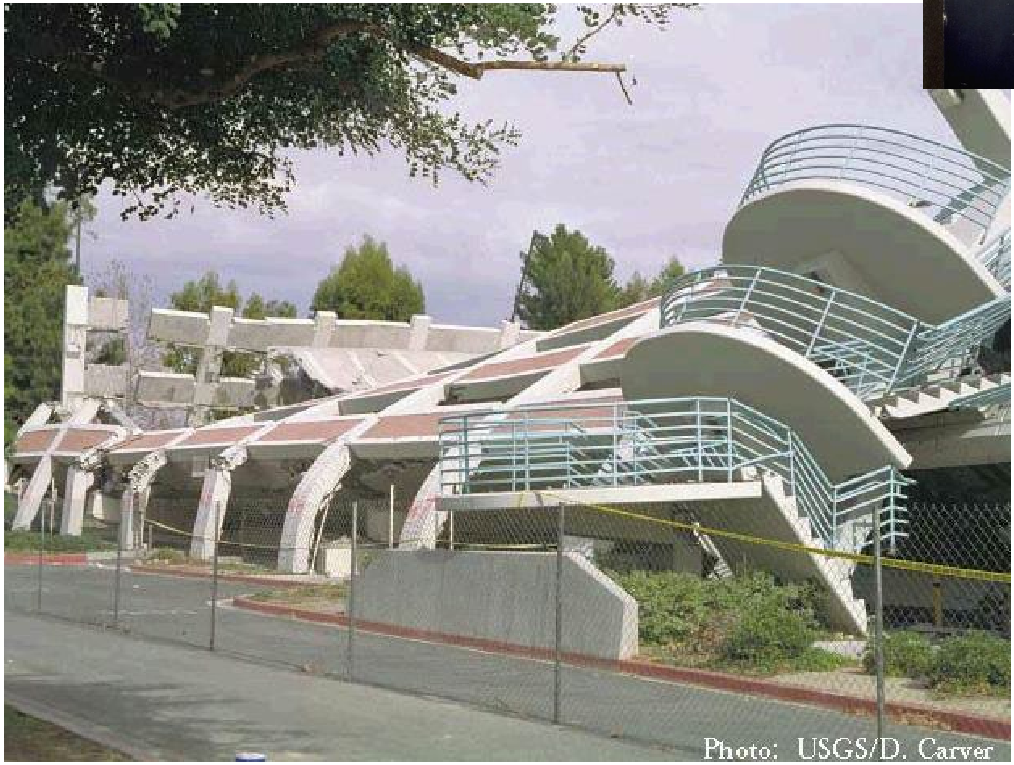
View to north northeast. San Gabriel Mountains in background.

Image courtesy of the USGS
Graphic modified from the Southern California Earthquake Center

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

Damage from the Northridge earthquake was extensive throughout the northern part of the Los Angeles metropolitan area. Hardest hit areas included the San Fernando Valley, Santa Monica, and Hollywood. More than 8,700 people were injured, including 1,600 who required hospitalization.

Sixteen people were killed when the Northridge Meadows apartment complex collapsed.
Image courtesy of FEMA News Photo



California State University, Northridge sustained very heavy damage – most notably the collapse of parking structures.
Image courtesy of D. Carver
U.S. Geological Survey

Teachable Moments

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The 1994 Northridge earthquake caused tens of thousands of landslides across southern California. The slides destroyed homes, blocked roads, disrupted pipe and power lines, and blocked streams.

Most of the mapped landslides occurred in the nearby Santa Susana and San Gabriel Mountains (top photo), where steep slopes are common.

Landslides at coastal bluffs, like the one pictured near Pacific Palisades (bottom photo) damaged homes and caused some to break loose and cascade down the bluffs.

Images courtesy of U.S. Geological Survey

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

Because the earthquake occurred early in the morning local time (4:30 am), only a few deaths resulted from the collapsed highway overpasses and the dozen bridges that fell onto freeway lanes.

The Santa Monica Freeway (below), one of the busiest in the country, collapsed during the quake and traffic had to be rerouted for several months.

Images courtesy of the USGS

This overpass had previously collapsed during the 1971 San Fernando Valley quake and demonstrated the problems with some early highway retrofitting measures. These were later improved after the 1994 quake.

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The 1994 Northridge earthquake (M 6.7) occurred in a heavily populated urban area northwest of Los Angeles and had many similarities to the 1971 San Fernando earthquake (also a M 6.7), which occurred in the same area.

These two earthquakes provide a unique opportunity to observe how north-south compression is accommodated in the Earth's crust. On a societal level, these two quakes—only 23 years apart—show how earthquake mitigation measures can improve our resilience against earthquake hazards and save lives in the process.

Image courtesy of the USGS

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

One of the real successes of earthquake preparedness in southern California was the Los Angeles City program to retrofit unreinforced masonry buildings (example shown). Since 1982, thousands of these buildings were repaired/retrofitted, many in areas that were strongly shaken by the 1994 Northridge quake.

It can be difficult to quantify the benefits of retrofitting, but the savings in lives and property for the Northridge earthquake alone more than justified this city ordinance.

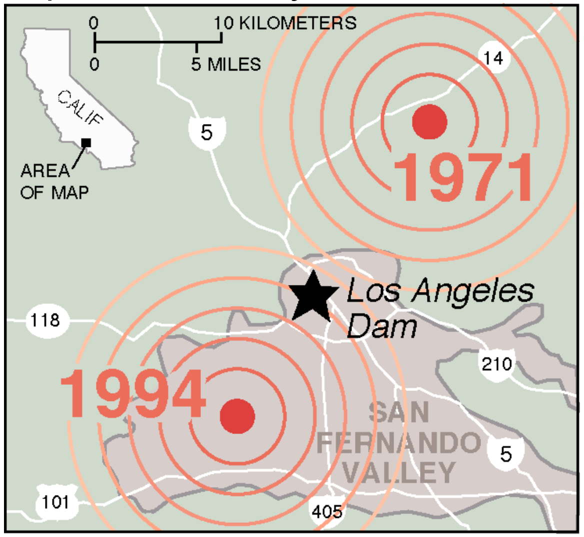
This masonry building near downtown Los Angeles was badly damaged during the Northridge earthquake. Prior retrofitting, evidenced by the lines of bolts (reddish, circular features indicated by the arrow), probably prevented more extensive collapse.

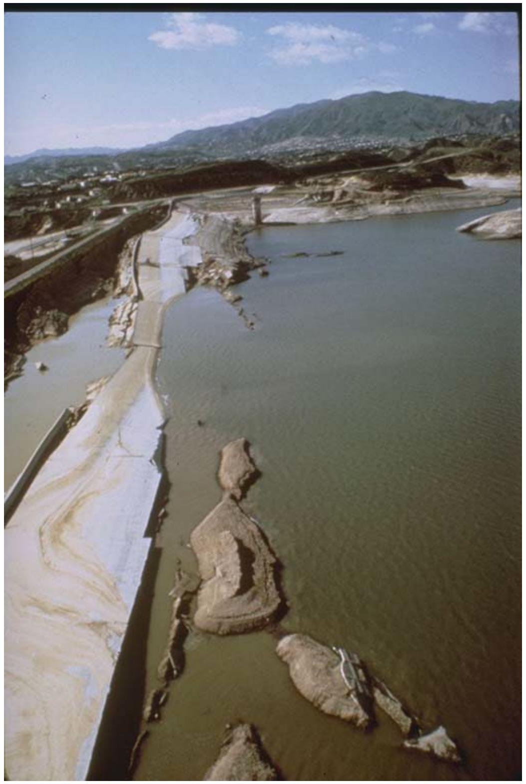
Image courtesy of the USGS

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

Map and photos courtesy of the USGS

Surface cracks from 1994 quake





Dam failure from 1971 quake

The Los Angeles dam complex sustained major damage in the 1971 San Fernando earthquake (far right photo). As a result of this near catastrophic event all dams in California were reevaluated and retrofitted.

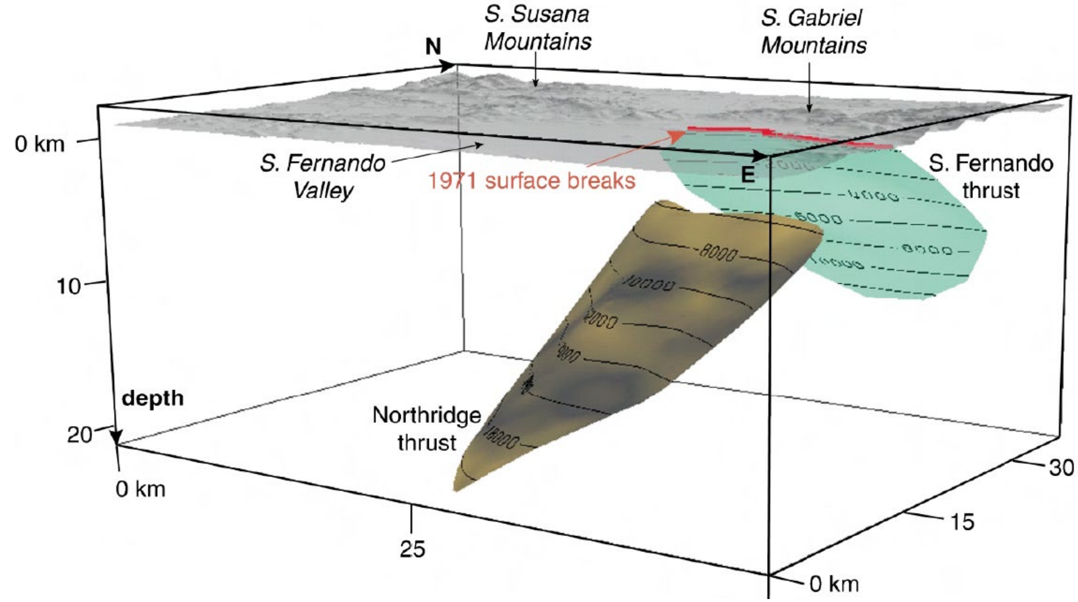
In contrast, the 1994 Northridge earthquake produced only minor cracks on the surface of the retrofitted dam (far left photo). Dam retrofit measures since 1971 included installation of at least 1,100 gravel columns, placed as conduits for ground water in an effort to reduce ground liquefaction and dam failure.

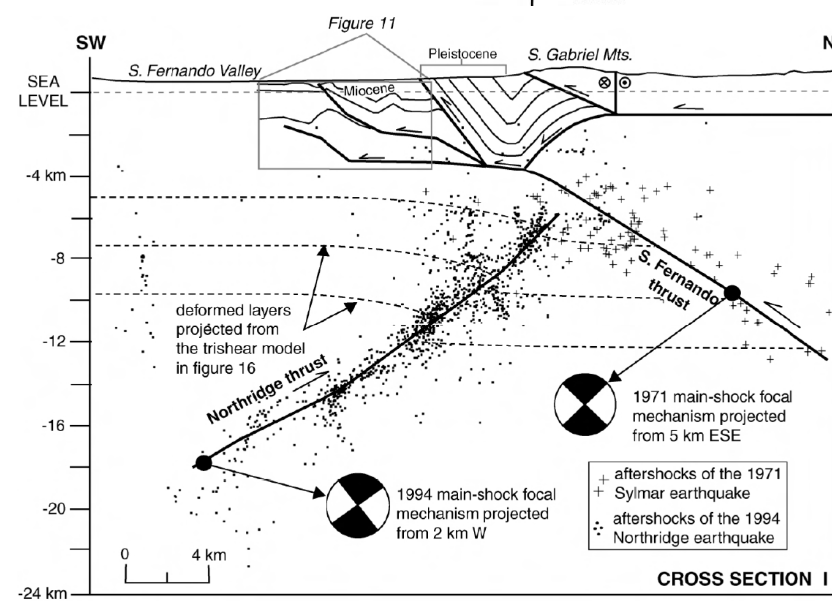
IRIS Teachable Moments

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The magnitude 6.7 earthquake that occurred in 1994 started at the hypocenter, ~12 miles beneath the San Fernando Valley. The rupture then propagated northward and upward to a depth of about 2 miles before stopping (brown surface in top figure at right). Unlike the nearby 1971 quake, the 1994 rupture never reached the surface.

The 1994 fault plane dips south underneath the San Fernando Valley at an angle of about 35° The hanging wall (upper San Fernando Valley block) moved northeasterly and up relative to the foot wall (lower San Gabriel Mountain block).





Block model courtesy C. Allen, Caltech

Figures from Carena and Suppe (2002)

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The image below is from a scientific paper that compares the aftershocks from the 1971 San Fernando Valley quake (red dots) with aftershocks from the 1994 Northridge quake (blue dots). The focal mechanisms for both quakes are also plotted at their respective hypocenters (1971 in red, 1994 in blue). This view provides a clear sense of the north-south compression in the crust (red arrows) that generated both of these earthquakes.

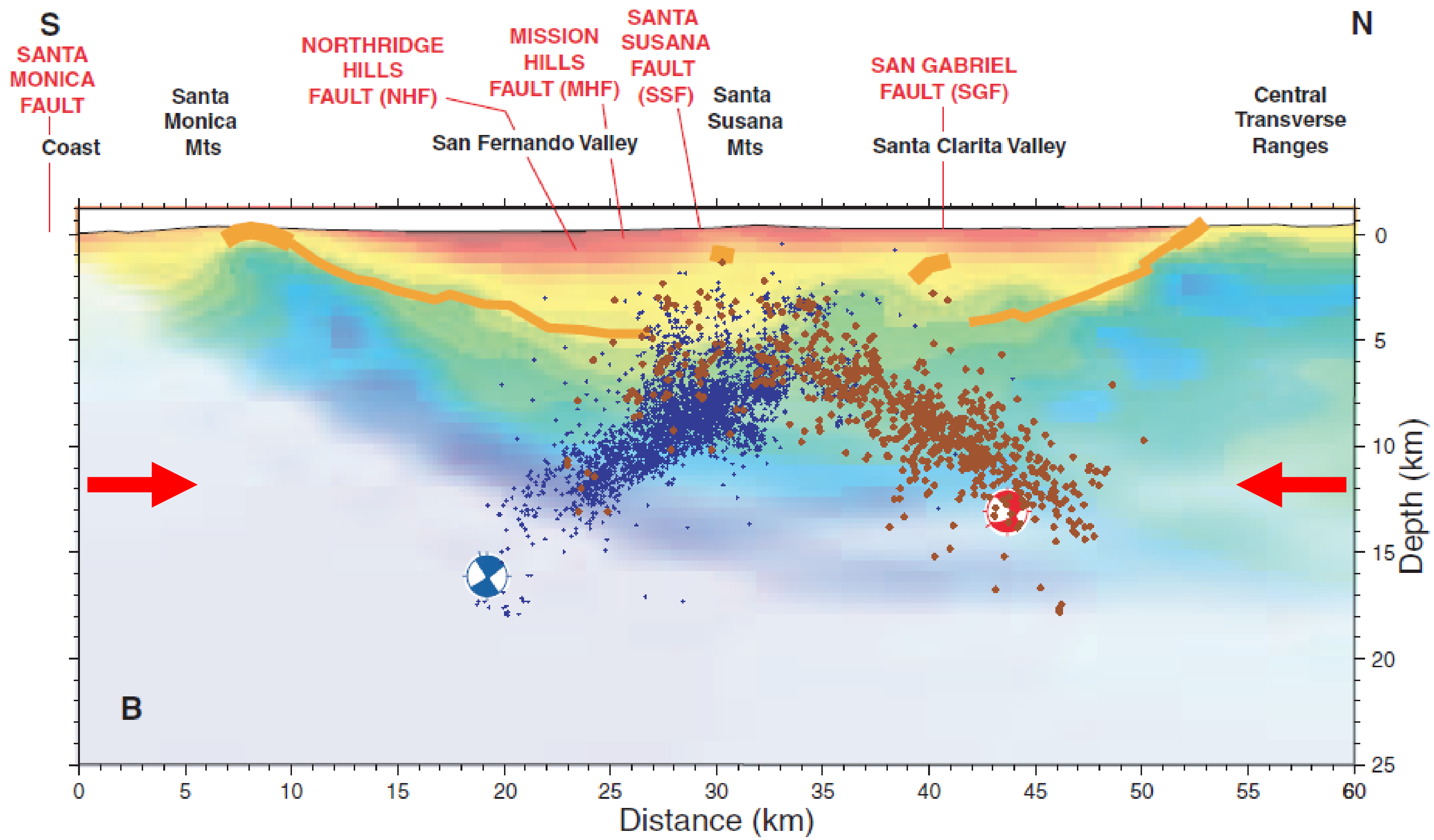


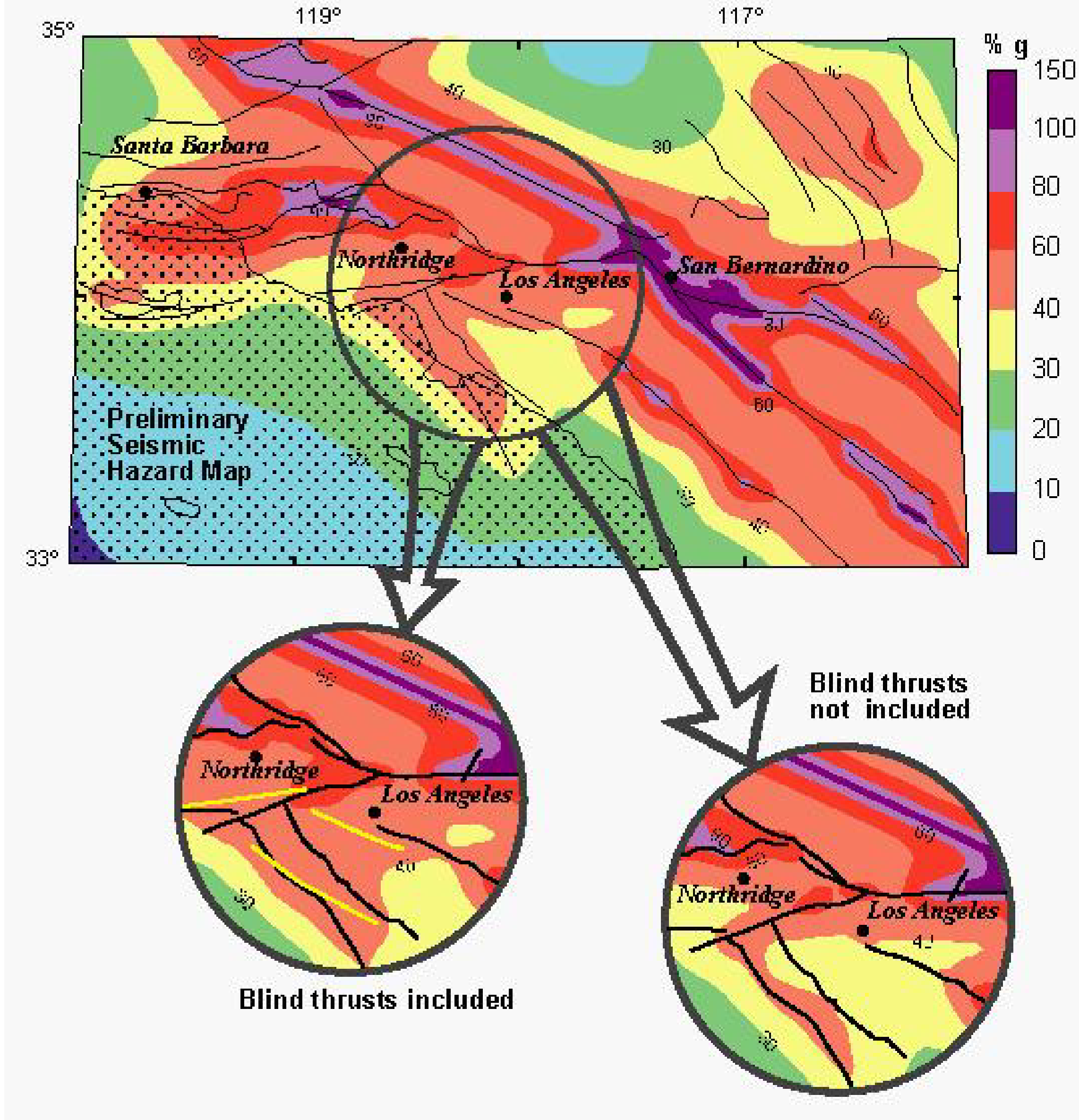
Figure from Fuis et al. (2003)

Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

Seismic Hazard Maps, like the one shown on the right, show where regions of most intense shaking are likely to occur based on the location of known and mapped faults.

The Northridge earthquake occurred on an unknown thrust fault that did not rupture to the surface. In the aftermath of the 1994 quake, hazard maps were updated to include the increased risk presented by known blind thrust faults (yellow lines), like the one that generated the Northridge quake.

These updated seismic hazard maps should more accurately reflect the shaking hazards from future earthquakes.

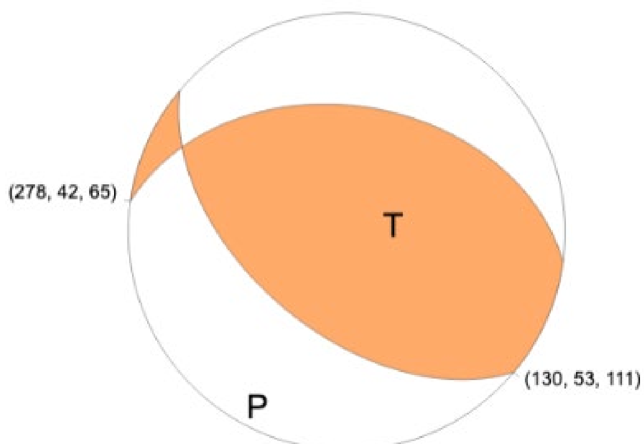


Figures courtesy of the USGS

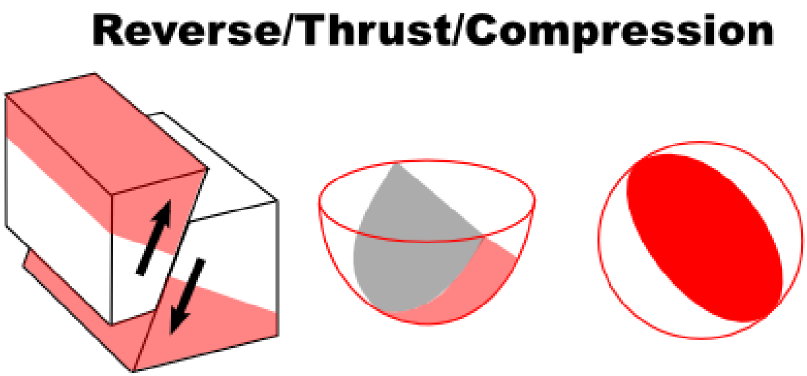
Magnitude 6.7 NORTHRIDGE
Monday, January 17, 1994 at 12:30:55 UTC

The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Since an earthquake occurs as slip on a fault, it generates primary (P) waves in quadrants of compression (shaded) and extension (white). The orientation of these quadrants determined from recorded seismic waves determines the type of fault that produced the earthquake.

The location, depth, and thrust-faulting mechanism of this earthquake suggest that it occurred as oblique-slip reverse faulting.



USGS W-Phase Moment Tensor Solution



The tension axis (T) reflects the minimum compressive stress direction. The pressure axis (P) reflects the maximum compressive stress direction.

Teachable Moments are a service of

The Incorporated Research Institutions for Seismology
Education & Public Outreach
and
The University of Portland

Please send feedback to tkb@iris.edu

To receive automatic notifications of new Teachable Moments subscribe at www.iris.edu/hq/retm

www.iris.edu/earthquake