

A magnitude 7.1 earthquake occurred 17km (10.6 miles) NNE of Ridgecrest, California at a depth of 17 km (10.6 miles). The earthquake was felt as far north as San Jose and as far south as Mexico.

This earthquake follows a magnitude 6.4 Thursday that we can now define as a foreshock. The energy released from a magnitude 7.1 earthquake is 11 times stronger than from a magnitude 6.4 earthquake.



Source: USGS Graphic: Sean O'Key, CNN, Map: Maps4news.com/@HERE



Gas leaks caused structure fires throughout Ridgecrest, residents reported water main breaks, and the power and communications were out in some areas. Several injuries have been reported.

> This photo shows damage on Highway 178 in Ridgecrest, Calif., following what is now known to be a M 6.4 foreshock on July 4, 2019. Both the M 6.4 and M 7.1 earthquakes shook a large swath of Southern California and parts of Nevada, rattling nerves and causing injuries and damage in the town near the epicenter.

> > (AP Photo/Matt Hartman)





The Modified-Mercalli Intensity (MMI) scale is a twelve-stage scale, from I to XII, that indicates the severity of ground shaking.

The area nearest the epicenter felt severe shaking from this earthquake.





USGS Estimated shaking Intensity from M 7.1 Earthquake



The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels.

30,000 people were exposed to severe shaking from this earthquake.



USGS PAGER Population Exposed to Earthquake Shaking



The color coded contour lines outline regions of MMI intensity. The total population exposure to a given MMI value is obtained by summing the population between the contour lines. The estimated population exposure to each MMI Intensity is shown in the table.

Image courtesy of the US Geological Survey



Locations of 5000 most recent earthquakes are shown.

At this latitude, the Pacific Plate is moving to the northwest with respect to the North American Plate at a rate of approximately 48 mm/yr.

The location of the earthquake falls within the Eastern California Shear Zone, a region of distributed faulting associated with motion across the Pacific -North American Plate boundary.



Map created with the IRIS Earthquake Browser



The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Because an earthquake occurs as slip on a fault, it generates primary waves in quadrants where the first pulse is compressional (shaded) and quadrants where the first pulse is extensional (white). The orientation of these quadrants determined from recorded seismic waves identifies the type of fault that produced the earthquake.

This earthquake occurred as a result of strike-slip faulting. Either right-lateral strike-slip faulting on a NW – SE fault plane OR left-lateral strike-slip faulting on a NE – SW fault plane are consistent with the focal mechanism.





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

Images courtesy of the U.S. Geological Survey





The San Andreas Fault is the transform plate boundary along which the Pacific Plate slides northwest with respect to the North American Plate. In southern California there are many intraplate faults within the Pacific and North American plates on both sides of the San Andreas. The Garlock Fault is a left-lateral strike-slip fault between the Mojave Desert and Sierra Nevada regions of southern California. The blue rectangle indicates the area of map on next slide.





Because the focal mechanism is consistent with left-lateral strike-slip faulting on a NE – SW fault plane, it is tempting to associate the July 6, 2019 earthquake with the Garlock Fault. However, the event is ~30 km north of the Garlock Fault. The blue rectangle indicates the map area on the next slide showing the July 4 to July 6, 2019 earthquake sequence.





Locations of the magnitude (M) 6.4 foreshock of July 4, the M7.1 mainshock of July 6, and 174 earthquakes of M \geq 3.0 in the July 4 – 6 sequence are shown on this map. Earthquakes are distributed along one NW-SE trend and another NE-SW trend. All focal mechanisms are consistent with right-lateral strike-slip faulting on a NW – SE fault plane or left-lateral strike-slip faulting on a NE - SW fault plane. This earthquake sequence lies within the western part of the Basin and Range Province and also within the Walker Lane – Eastern California Shear Zone.



The map on the right shows the July 4 – 6, 2019 earthquake sequence and broad tectonic zones of California and the Great Basin.

Most of the relative motion between the Pacific and North American Plates occurs on the San Andreas Fault. However, 15% to 25% of that relative plate motion occurs within the Walker Lane – Eastern California Shear Zone.

The right-lateral displacement on the NW-SE oriented fault plane during the July 6 mainshock is likely related to distributed right-lateral shearing within the Walker Lane – Eastern California Shear Zone.



Image courtesy of the U.S. Geological Survey



Animating four days of seismicity from July 3 – July 6th allows visualization of the different windows of this earthquake sequence. From calm to the magnitude 6.4 foreshock (and aftershocks) to the magnitude 7.1 (and aftershocks).

There are 2,492 earthquakes plotted in this four-day animation.



Animation created with the IRIS Earthquake Browser



A "mainshock" is largest magnitude earthquake during an earthquake sequence.

A "foreshock" is a smaller magnitude earthquake that precedes the mainshock.

"Aftershocks" are smaller earthquakes occurring after a large earthquake as the fault adjusts to the new state of stress.

Although seismologists have carefully analyzed foreshock/mainshock pairs of earthquakes, and earthquake triggering in general, there are no special characteristics of a foreshock that let us know it is a foreshock until the mainshock occurs.



Foreshock – Mainshock – Aftershock Animation



Aftershock sequences follow predictable patterns as a group, although the individual earthquakes are themselves not predictable. The graph shows how the number of aftershocks and the magnitude of aftershocks decay with increasing time since the main shock. The number of aftershocks also decreases with distance from the main shock.



>M 4 July 4 - 5, 2019



Image and text courtesy of the US Geological Survey





>M 4 July 6, 2019



While commonly plotted as points on maps, earthquakes of this size are more appropriately described as slip over a larger fault area. The duration of the slip in this earthquake was approximately 20 seconds.

This plot shows a cross section of the slip distribution during the earthquake. Maximum slip is modeled at approximately 3 meters. The USGS notes that the deep slip at NW end of fault is unlikely to be real and just a data processing issue.



Image courtesy of the US Geological Survey

Teachable Moments

15-

14-

13-

Magnitude 7.1 RIDGECREST, CALIFORNIA Saturday, July 6, 2019 at 03:19:52 UTC

The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 1021 km (634 miles, 9.2°) from the location of this earthquake.

Following the earthquake, it took 2 minutes and 12 seconds for the compressional P waves to travel a curved path through the crust and mantle to Bend, Oregon.



Time (Minutes

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 <u>www.iris.edu/hq/retm</u>





