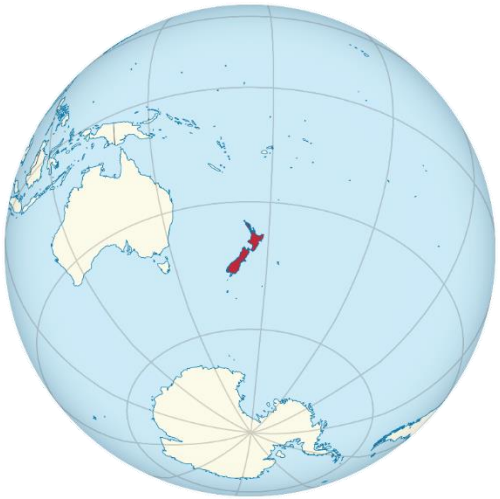
Magnitude 7.8 SOUTH ISLAND OF NEW ZEALAND

Sunday, November 13, 2016 at 11:02:57 UTC



A magnitude 7.8 earthquake hit the east coast of New Zealand's South Island just before midnight local time Sunday, triggering multiple aftershocks and tsunami waves. The earthquake struck about 93 km (58 miles) north of Christchurch at a depth of 23 km (14 miles). Two people are reported dead, and the extent of the property damage is still unknown with some small towns cut off due to landslides.

A landslide blocks State Highway One and the main railway line north of Kaikoura following an earthquake in New Zealand, Monday, Nov. 14, 2016. A powerful earthquake that rocked New Zealand on Monday triggered landslides and a small tsunami, cracked apart roads and homes and left two people dead, but largely spared the country the devastation it saw five years ago when a deadly earthquake struck the same region.

(Mark Mitchell/New Zealand Herald/Pool via AP)

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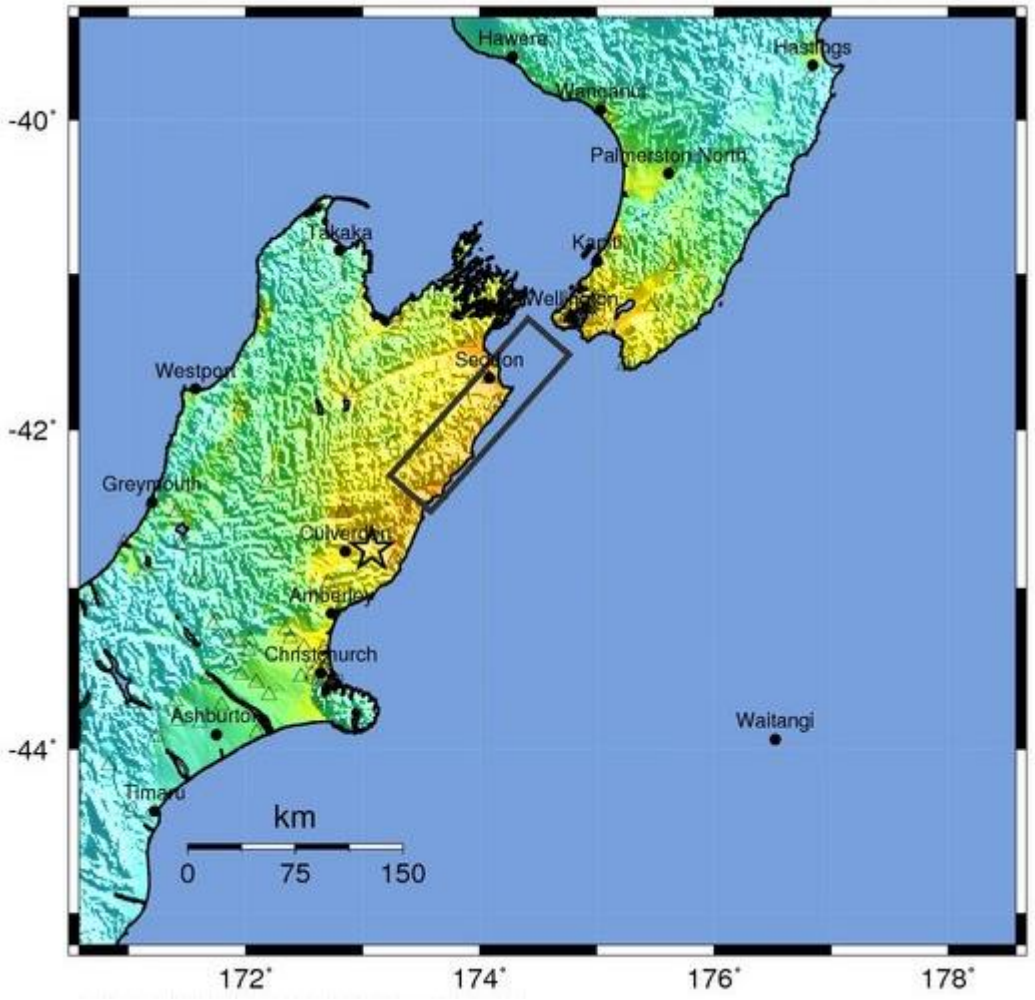
The Modified-Mercalli Intensity scale is a twelve-stage scale, from I to XII, that indicates the severity of ground shaking.

A wide area felt strong to very strong shaking from this earthquake.

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

Image courtesy of the US Geological Survey



USGS Estimated shaking Intensity from M 7.8 Earthquake

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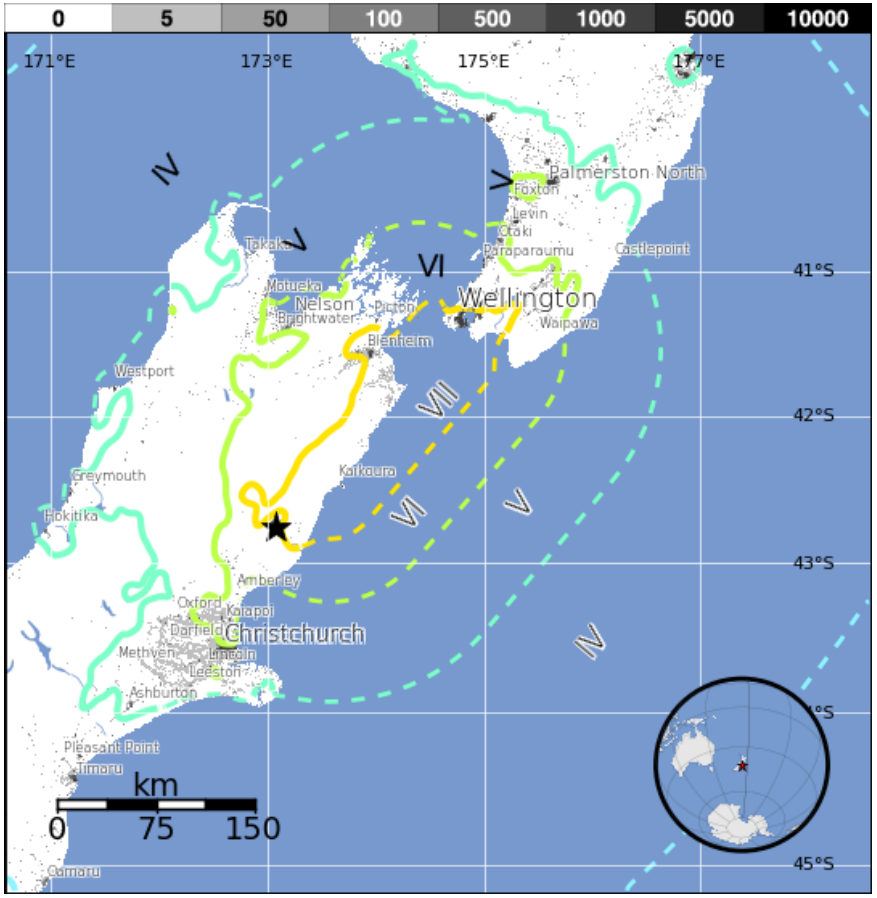
The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels.

The USGS approximates 3,000 people were exposed to severe shaking from this earthquake.

MMI	Shaking	Pop.
I	Not Felt	--*
II-III	Weak	0 k*
IV	Light	140 k*
V	Moderate	527 k
VI	Strong	779 k
VII	Very Strong	240 k
VIII	Severe	3 k
IX	Violent	0 k
X	Extreme	0 k

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

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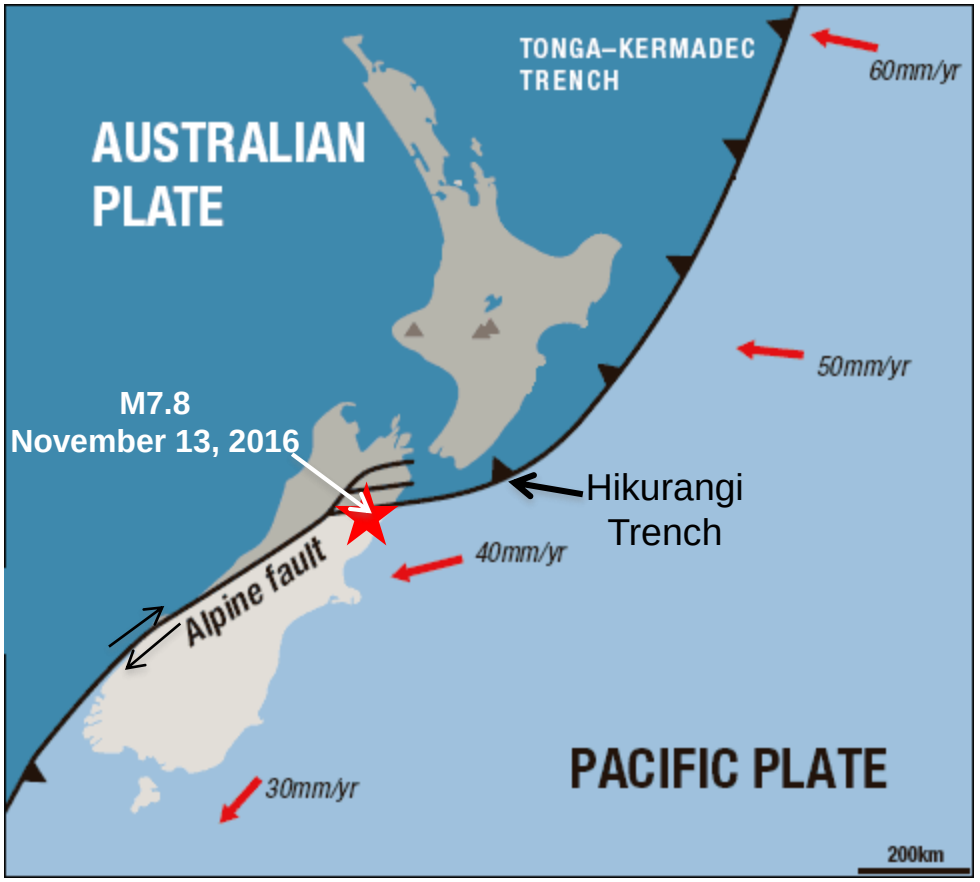
Regional Tectonics

The much larger southeastern part of the South Island of New Zealand is on the Pacific Plate while the smaller northern part of the South Island is on the Australian Plate.

At the northeast end of the Alpine fault, the Australian - Pacific Plate boundary transitions from right-lateral transform to the southwest into a convergent boundary along the Hikurangi Trench.

The M7.8 November 13, 2016 earthquake occurred within this zone of oblique compression.



Modified from the New Zealand Herald

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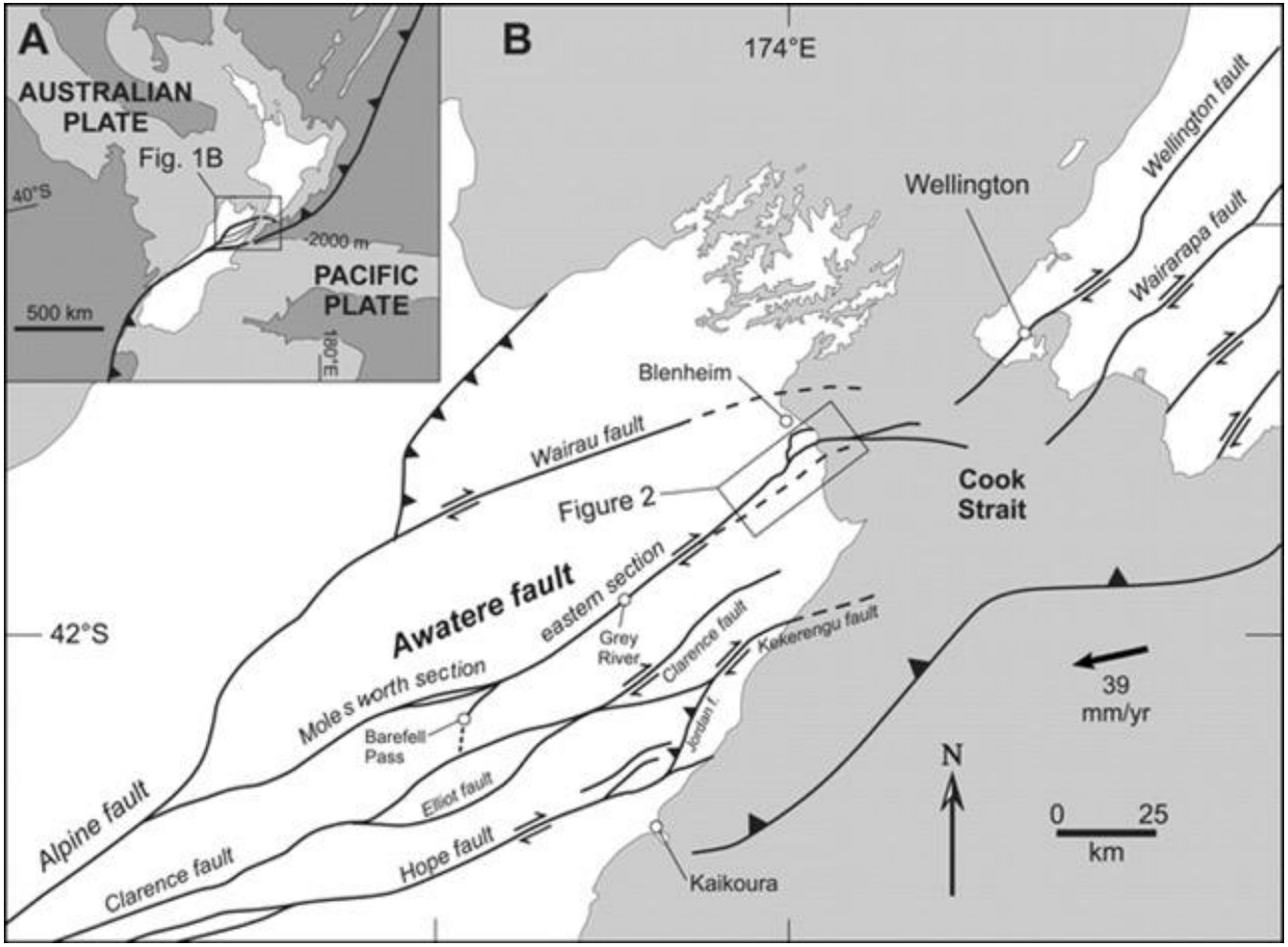
The plate boundary in the region of the earthquake is complex, involving a transition from subduction along the Hikurangi Trench to the east of the North Island, to transform faulting through the South Island.



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IRIS Teachable Moments

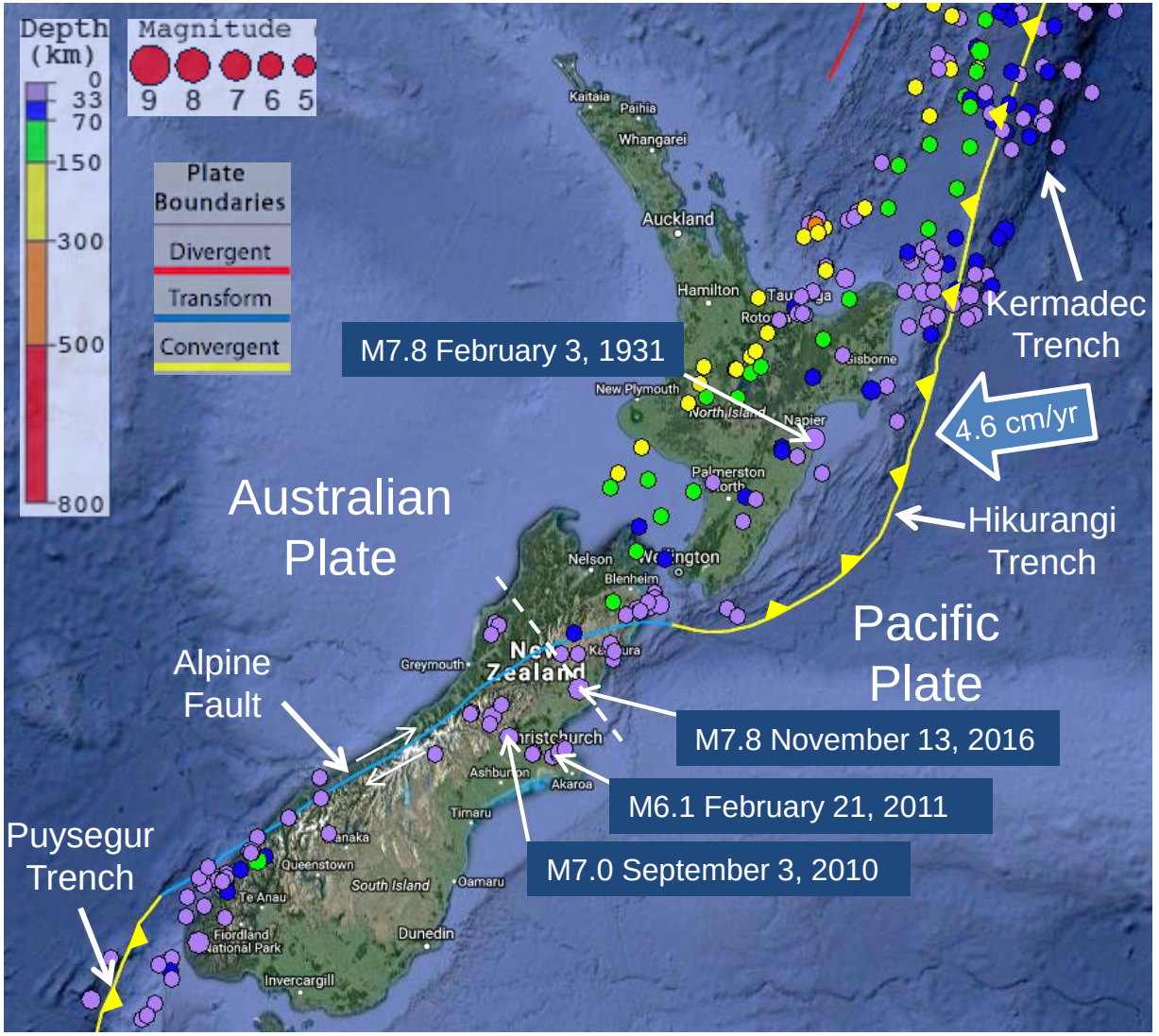
This regional map shows epicenters of the 234 M≥5.5 earthquakes that have occurred in New Zealand since 1970.

The M7.8 November 13, 2016 earthquake is the largest to occur in New Zealand since the M7.8 Hawke's Bay earthquake on February 3, 1931.

Also labeled are the epicenters of the M7.0 September 3, 2010 and the M6.1 February 21, 2011 earthquakes that heavily damaged Christchurch.

The dashed white line indicates the location of the cross section in next slide.

Earthquake and Historical Seismicity



Map created with the IRIS Earthquake Browser

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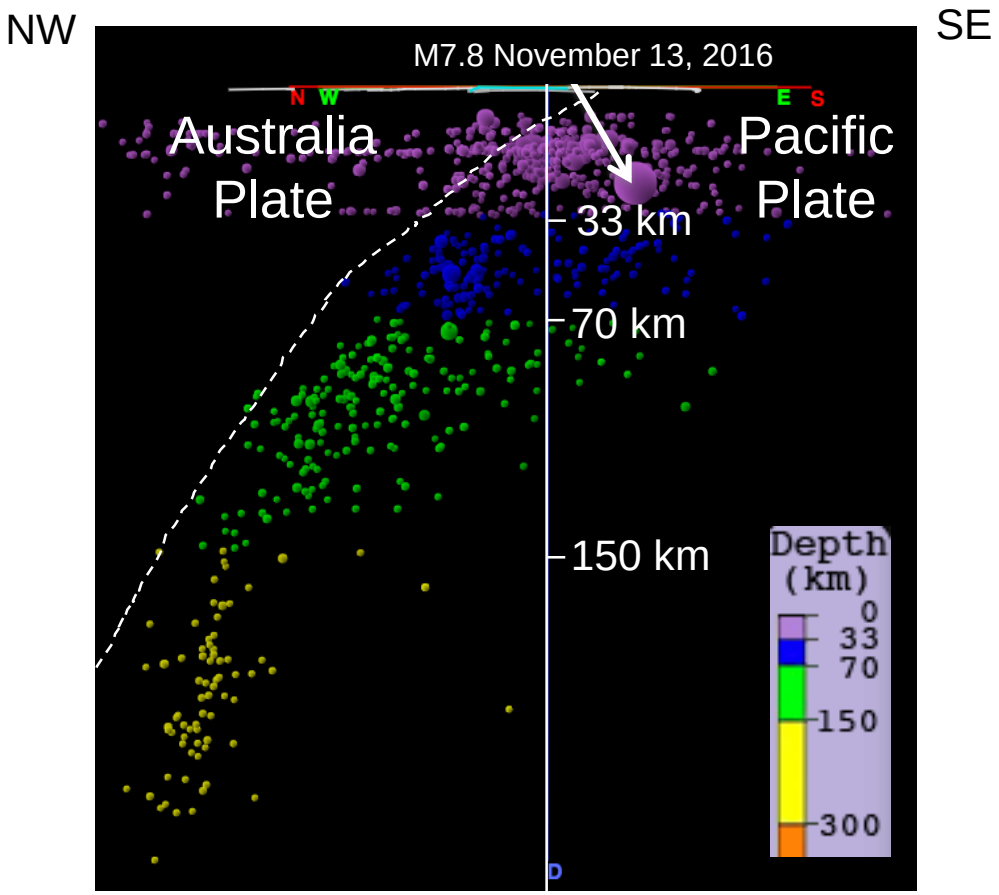
The hypocenter of the M7.8 earthquake is shown on this NW – SE oriented cross section of seismicity. Hypocenters of 907 additional events of M≥4 are illustrated. The direction of view is towards the northeast roughly parallel to the Alpine Fault.

The dashed white line approximates the top of the Pacific Plate as it subducts beneath the Australia Plate at the Hikurangi Trench.

The M7.8 November 13, 2016 earthquake occurred within the Pacific Plate on or near the plate boundary with the Australian Plate.



Cross section created with the IRIS Earthquake Browser

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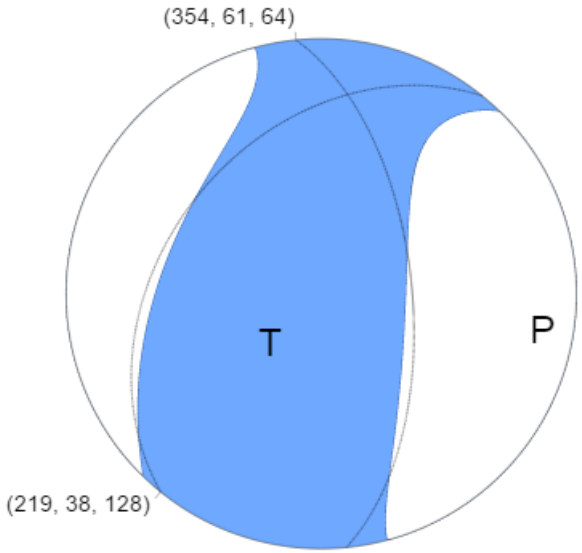
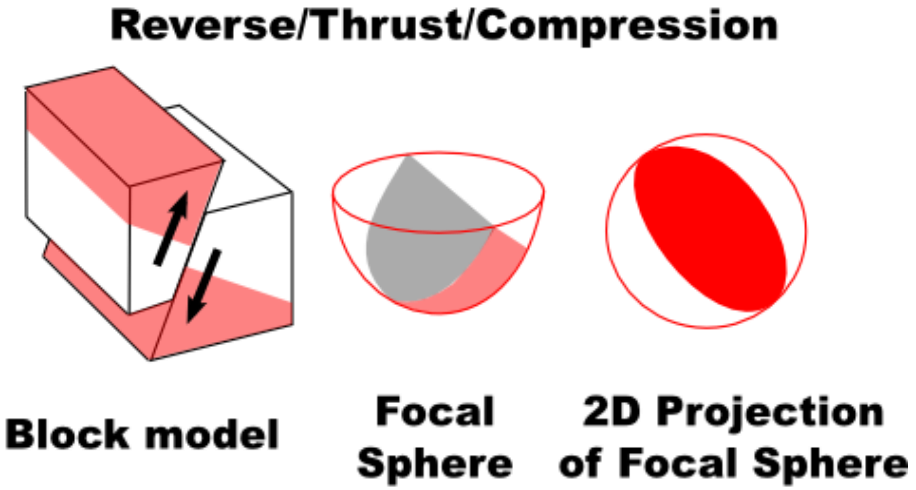
Based on the size, depth, and faulting orientation, this earthquake occurred as the result of shallow oblique-reverse faulting on or near the boundary between the Pacific and Australian Plates.



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.

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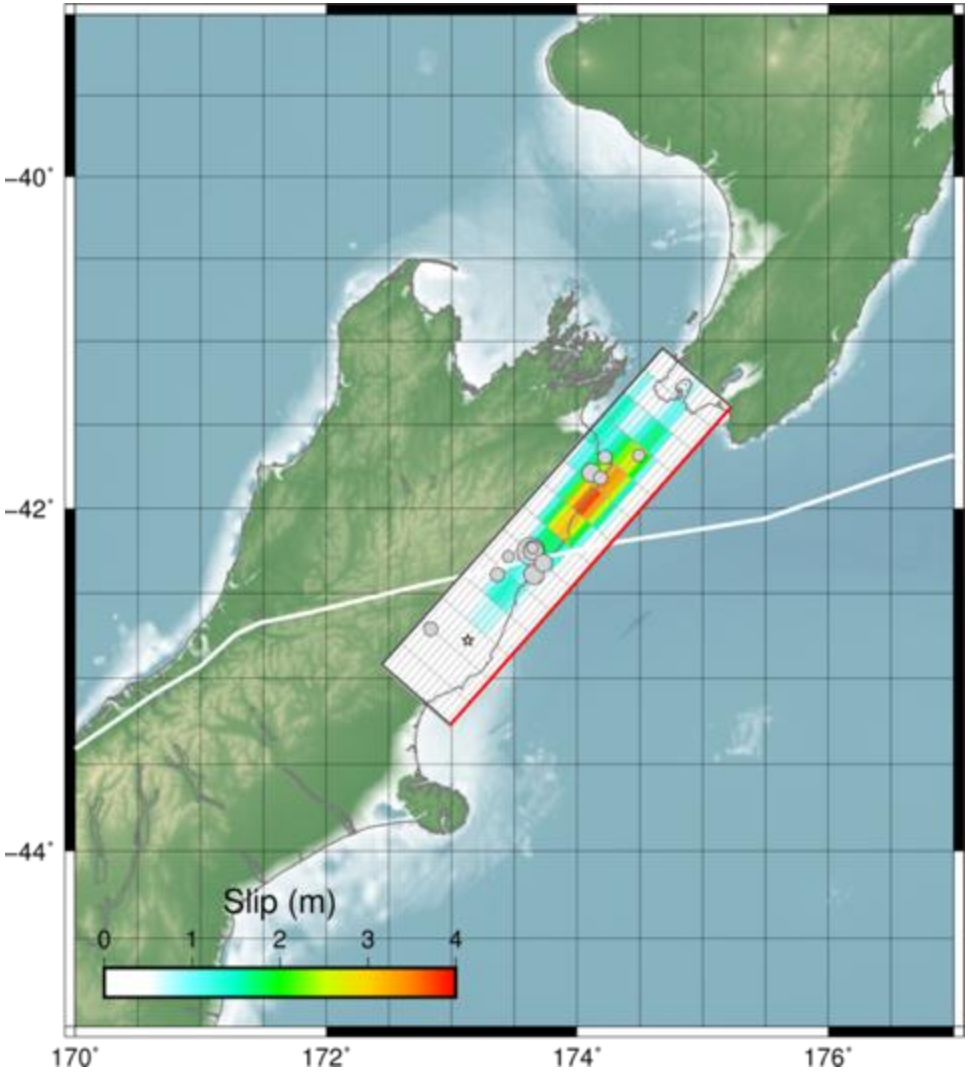
While commonly plotted as points on maps, earthquakes of this size are more appropriately described as slip over a larger fault area.

This map shows a cross section of the slip distribution during the earthquake plotted on the regional map. Maximum slip is modeled at approximately 4 meters.

According to the USGS, because of the complexity of this plate boundary region, strain is being accommodated on many different structures of varying orientations, making it possible that more than one fault may be activated in this earthquake sequence.



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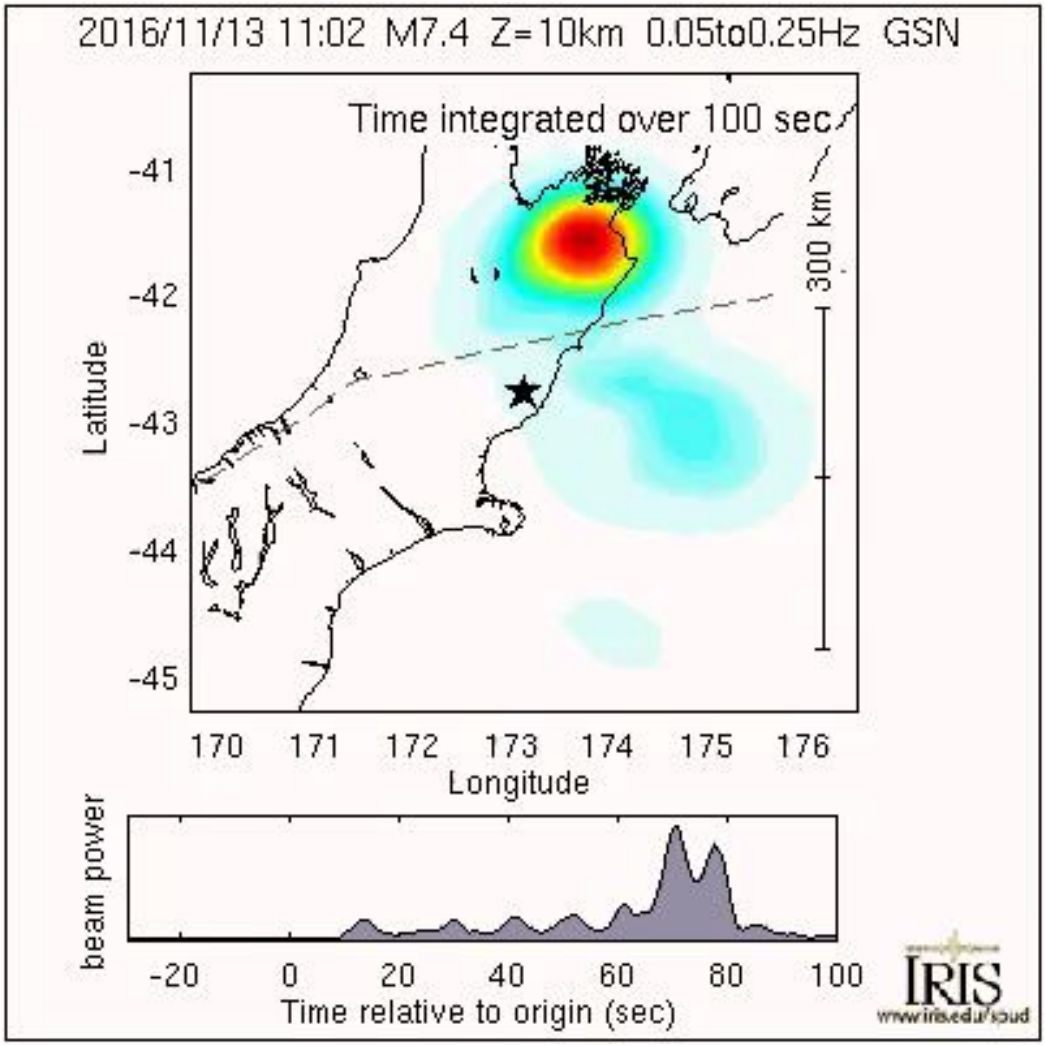
Back Projections are movies created from an automated data processing sequence that stacks up P wave energy recorded on many seismometers on a flat grid around the source region. This grid is meant to be a fault surface and creates a time and space history of the earthquake.

Warmer colors indicate greater beam power.

This event has an extremely complex source. The source-time function is about 100 sec in duration, with a secondary moment release starting about 50 sec after origin time.



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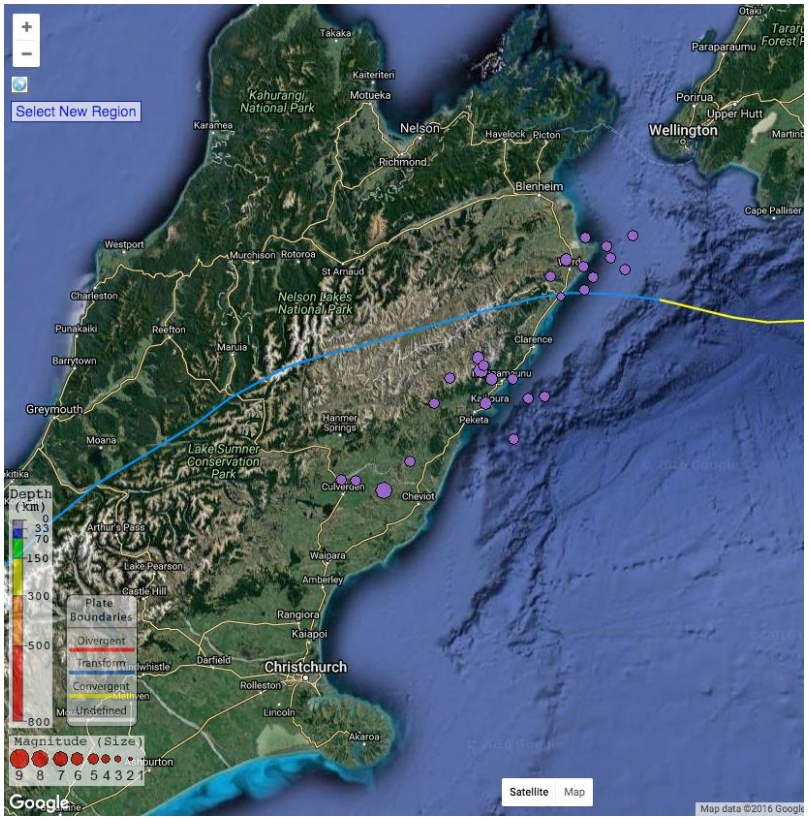
Numerous aftershocks have occurred in the hours following the M7.8 earthquake, including one M6.5, two other M6+ events, and 21 M4.5 to M5.9 events plotted on the map to the right. Aftershocks are primarily occurring in the vicinity of the main slip.

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.



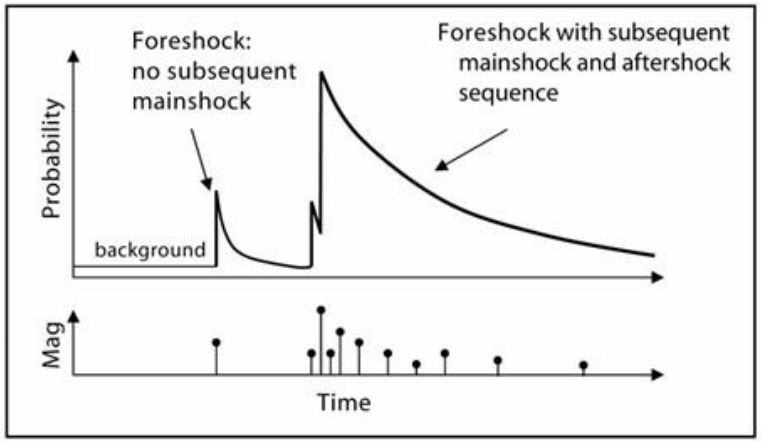


Image and text courtesy of the US Geological Survey

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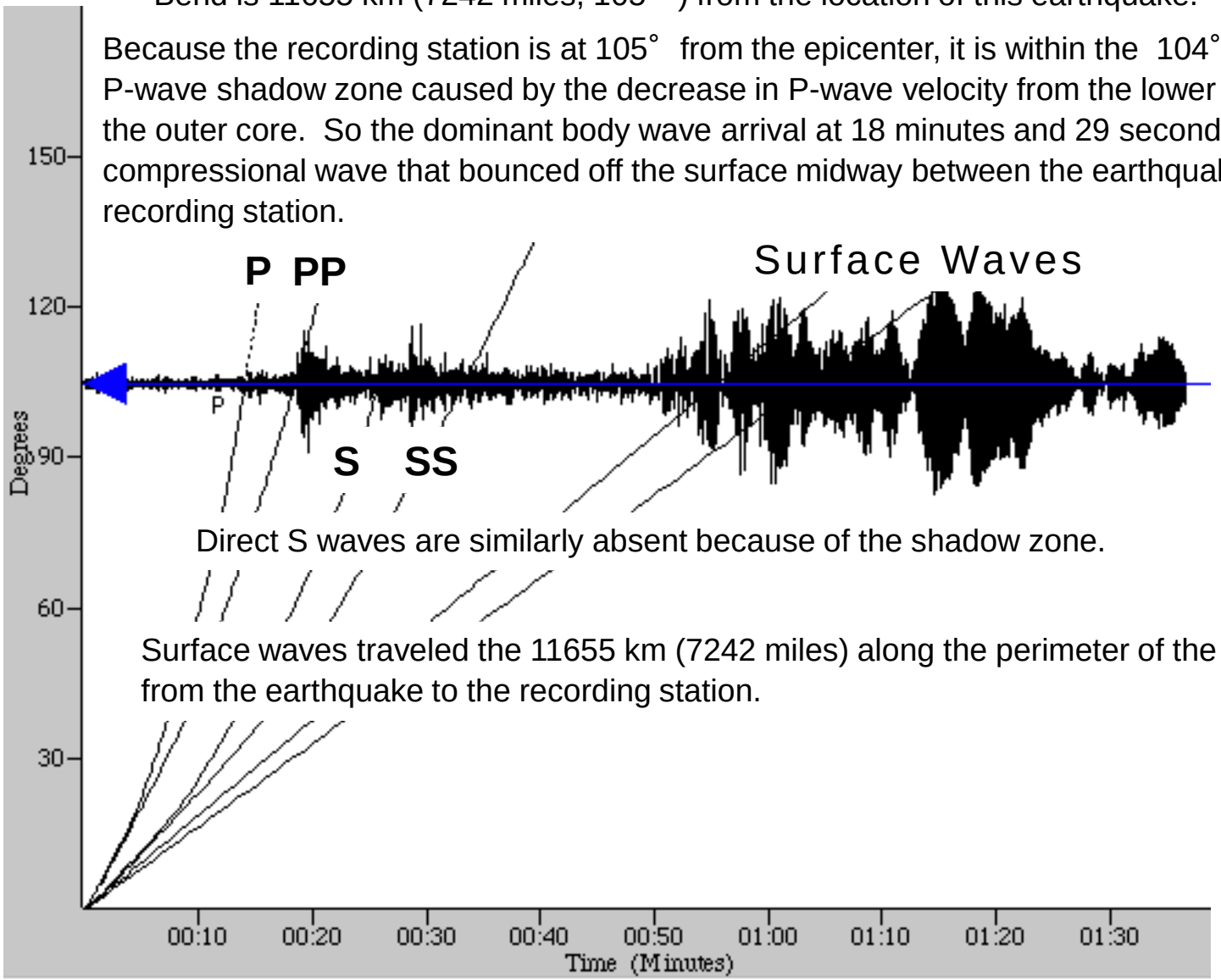
The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 11655 km (7242 miles, 105˚) from the location of this earthquake.

Because the recording station is at 105˚ from the epicenter, it is within the 104˚ to 140˚ P-wave shadow zone caused by the decrease in P-wave velocity from the lower mantle into the outer core. So the dominant body wave arrival at 18 minutes and 29 seconds is PP, the compressional wave that bounced off the surface midway between the earthquake and the recording station.



Direct S waves are similarly absent because of the shadow zone.

Surface waves traveled the 11655 km (7242 miles) along the perimeter of the Earth from the earthquake to the recording station.

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