Magnitude 7.0 SOUTH ISLAND OF NEW ZEALAND

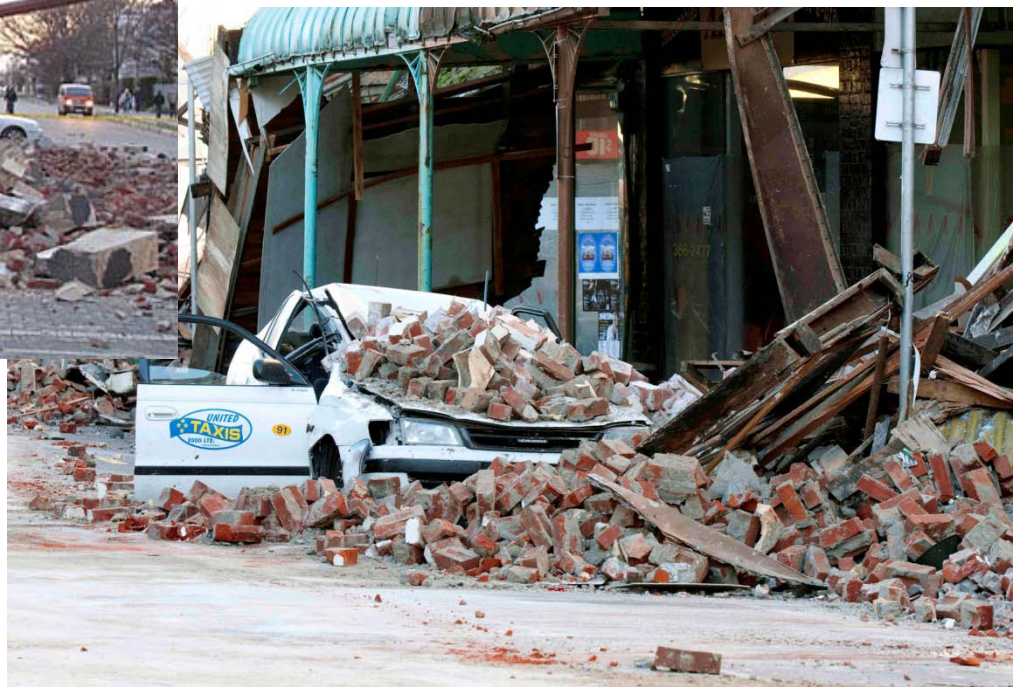
Friday, September 3, 2010 at 16:35:46 UTC

USGS

A powerful 7.0-magnitude earthquake shook much of New Zealand's South Island early Saturday morning local time.

A damaged building near Manchester St.

New Zealand Herald Photo / Colin Cross



A car damaged by rubble from a building is seen following a 7.0-magnitude earthquake in central Christchurch, New Zealand, early Saturday, Sept. 4, 2010.

AP Photo/NZPA, David Alexander

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Reported on msnbc.com:

Authorities declared an overnight curfew for Saturday after a major earthquake hit New Zealand's second-biggest city. Christchurch and its neighboring small towns bore the full force of the quake, which brought down power lines and bridges and wrecked roads and building facades. However, no deaths and only two injuries were reported.

Still, infrastructure damage was major, with "a lot of damage to our key infrastructure ... water, waste water (sewerage) systems.“

"The damage is immense, it's something that has affected every family, every household...the hit on our infrastructure, the pipes that deliver the water, the waste water, the bridges, the power supplies ... has been very significant," Christchurch mayor Bob Parker told reporters.

Roads had been blocked by rubble, gas and water supplies disrupted, while chimneys and walls had fallen from older buildings, Parker added. He warned that continuing aftershocks could cause masonry to fall from damaged buildings.

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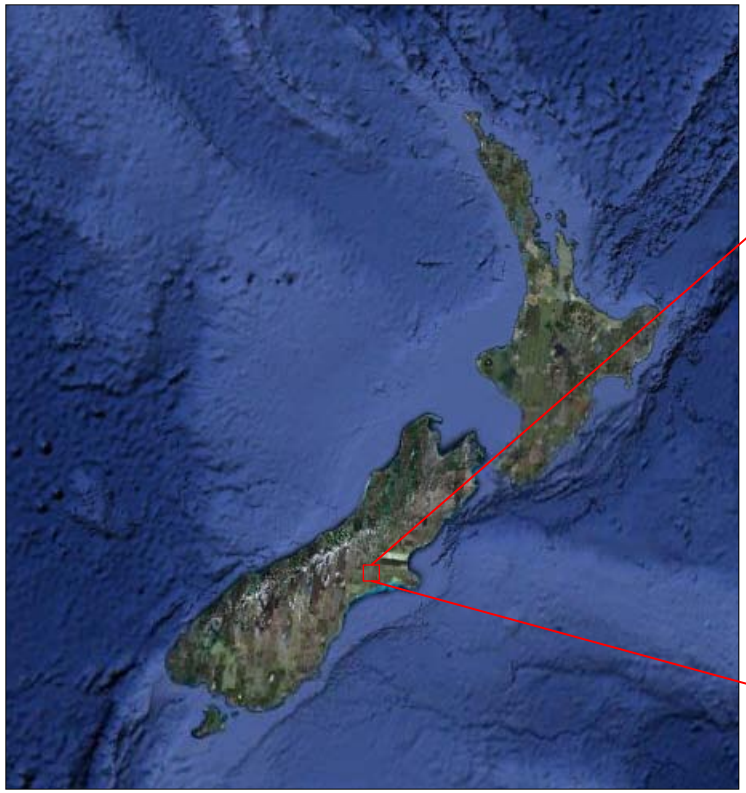
This earthquake occurred as a result of strike-slip faulting within the crust of the Pacific plate, near the eastern foothills of the Southern Alps at the western edge of the Canterbury Plains. The earthquake struck approximately 50 km to the west-northwest of Christchurch, the largest population center in the region.



Google Earth™ mapping service

Canterbury region of New Zealand's South Island from *http://www.amazingspace.co.nz/amazing/*

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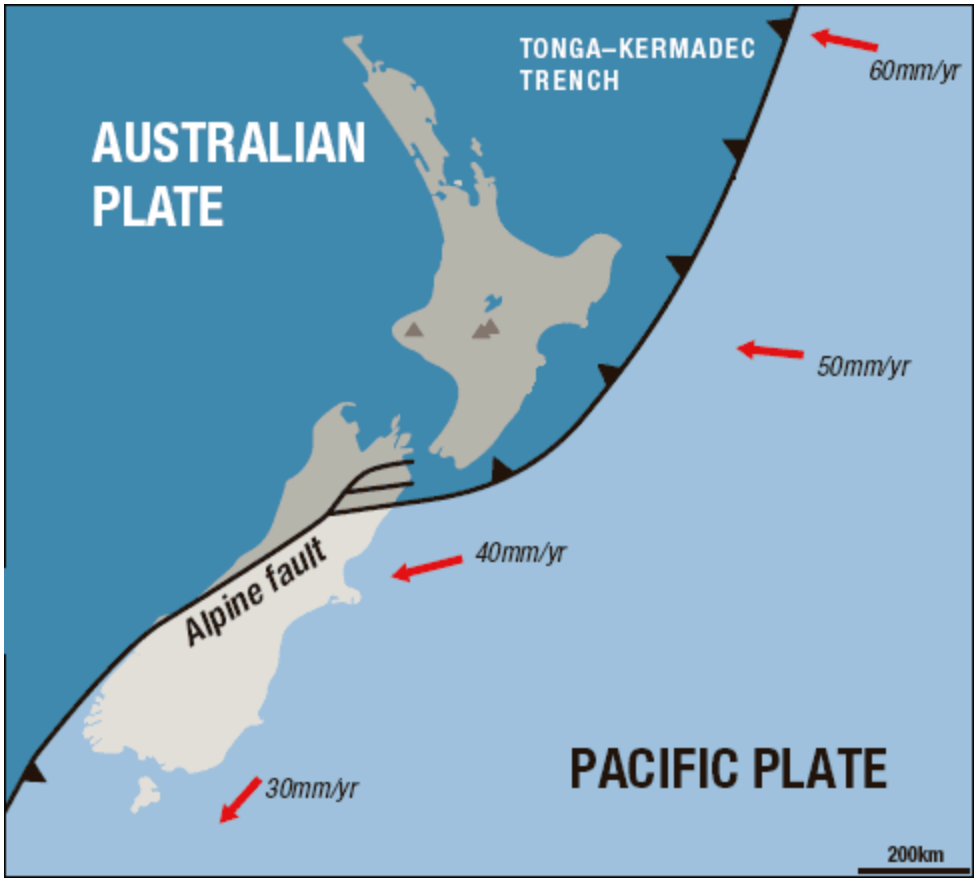
Regional Tectonics

The South Island of New Zealand is cut by the Alpine fault that forms a transform boundary between the Pacific and Australian plates.

The earthquake, though removed from the plate boundary itself, appears to reflect right-lateral motion on a previously unmapped fault that is related to the overall relative motion of these plates.



Modified from the New Zealand Herald

This plate boundary is similar to the situation in California where the San Andreas Fault forms the transform boundary between the Pacific and North American plates. In New Zealand, the much larger southeastern part of the South Island is on the Pacific Plate while the smaller northern part of the South Island is on the Australian Plate.

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Earthquake and Historical Seismicity

This earthquake (gold star), plotted with regional seismicity since 1990, occurred as a result of strike-slip motion on a previously unmapped fault within the crust of the Pacific plate.

This earthquake was 80-90 km to the south and east of the Australia-Pacific plate boundary through the island, the Alpine fault (green line). Further to the north on the southern island of New Zealand, the single Alpine fault transitions to multiple faults that make up the Marlborough Fault Zone.

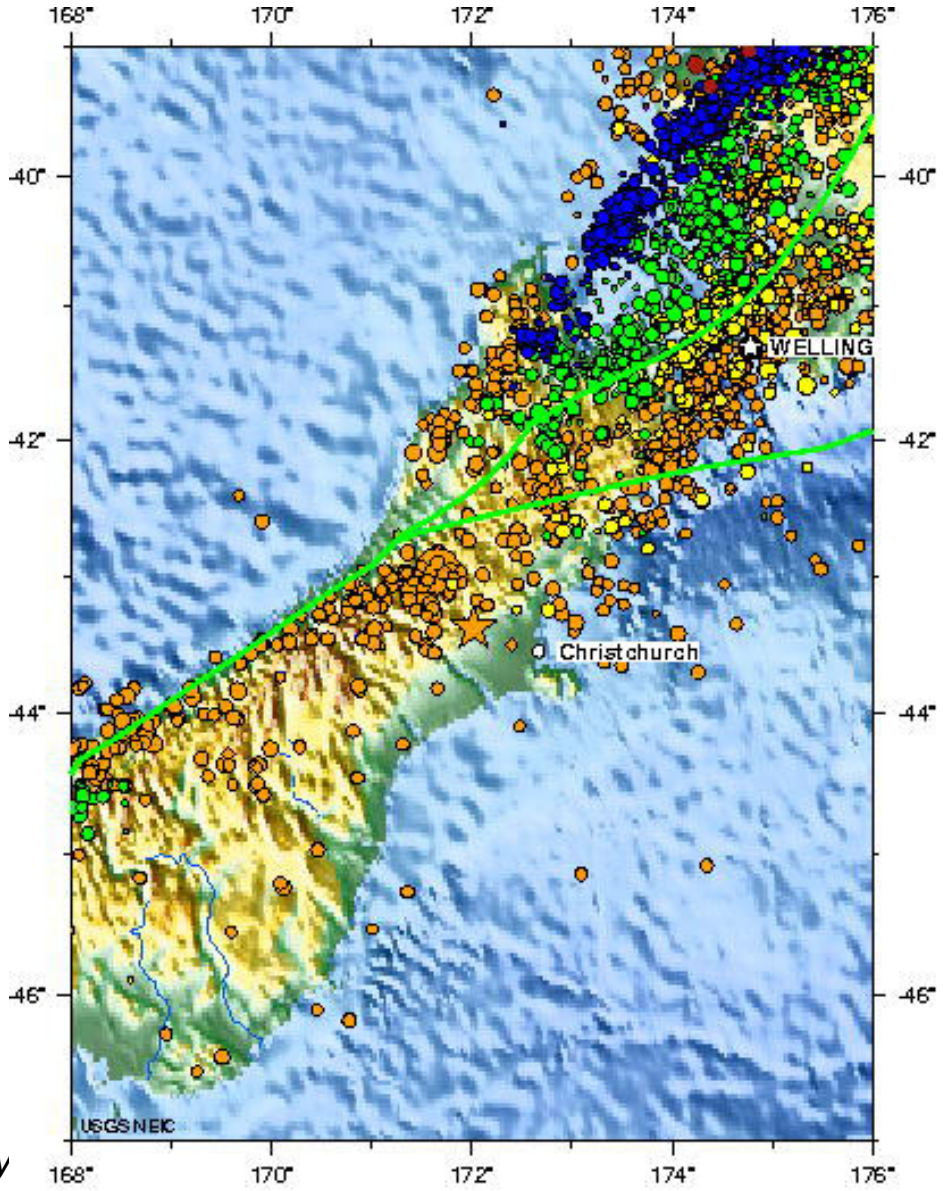

Image courtesy of the US Geological Survey

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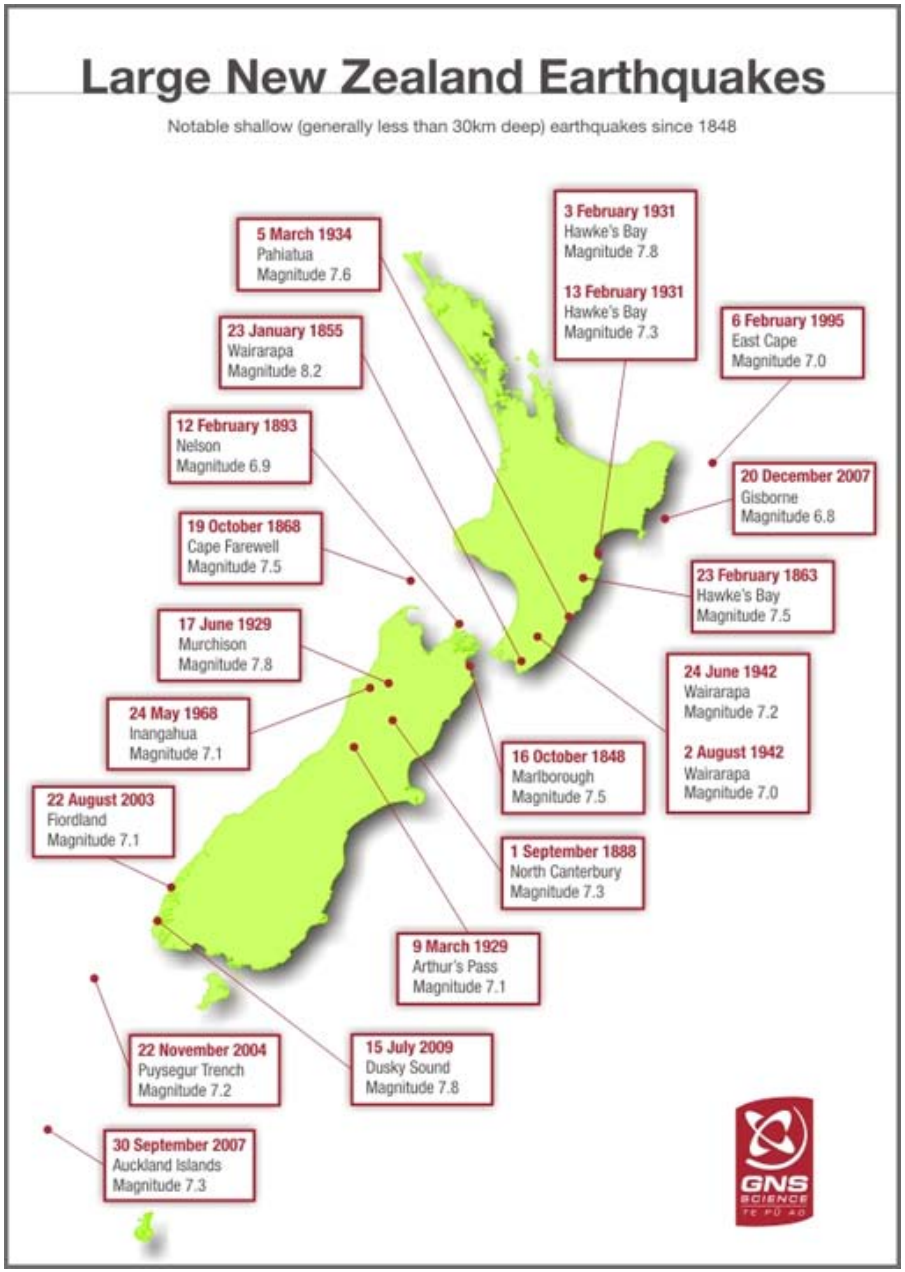
This map shows notable shallow earthquakes since 1848. This history has helped this region prepare for earthquakes, and this preparation made it possible for this earthquake to not result in loss of life.

The M7.0 earthquake occurred approximately 50 km to the southeast of a M7.1, surface-rupturing event in Arthur's Pass, on March 9th, 1929, which caused 17 fatalities. - *Quoted from USGS*

More recently, two earthquakes of M6.7 and M5.9 occurred in June 1994 approximately 40 km to the northwest of today's event, but did not cause any known fatalities or significant damage.
- *Quoted from USGS*



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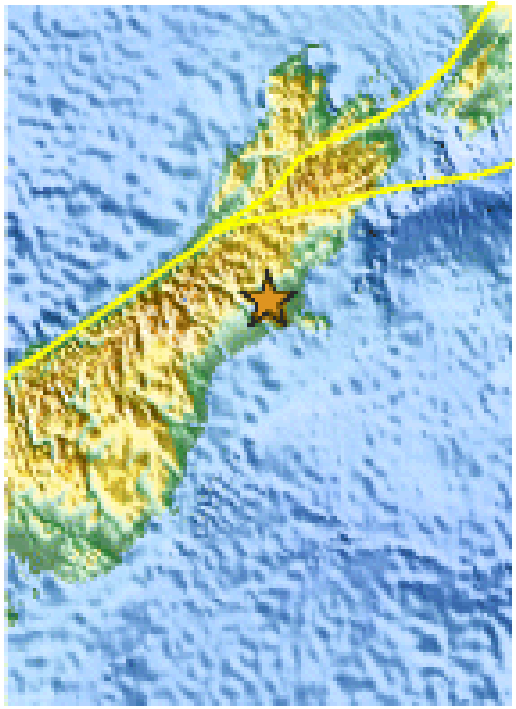
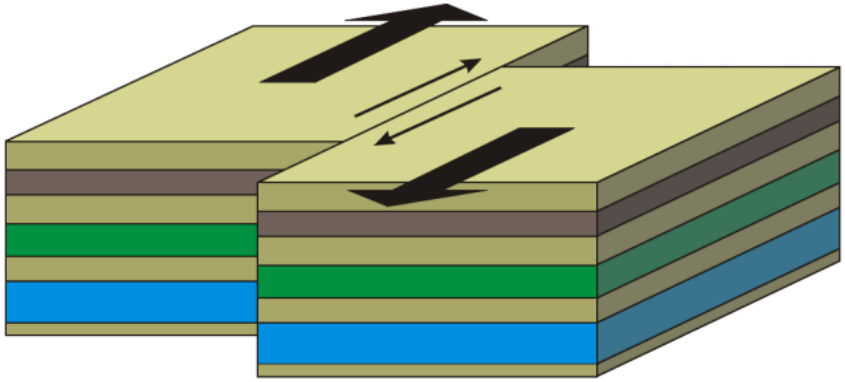
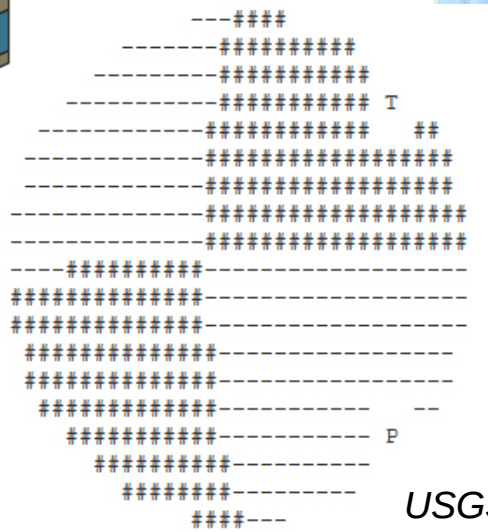
The location and focal mechanism of the earthquake appear to reflect right-lateral motion on a previously unmapped fault that is within the crust of the Pacific plate about 80-90 km to the south and east of the current expression of the Australia - Pacific plate boundary through the island (Alpine Fault).



USGS



In a strike-slip fault, the fault surface is usually near vertical and the offset is either to the left or right with very little vertical motion.



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

USGS Centroid Moment Tensor

Images courtesy of the US Geological Survey

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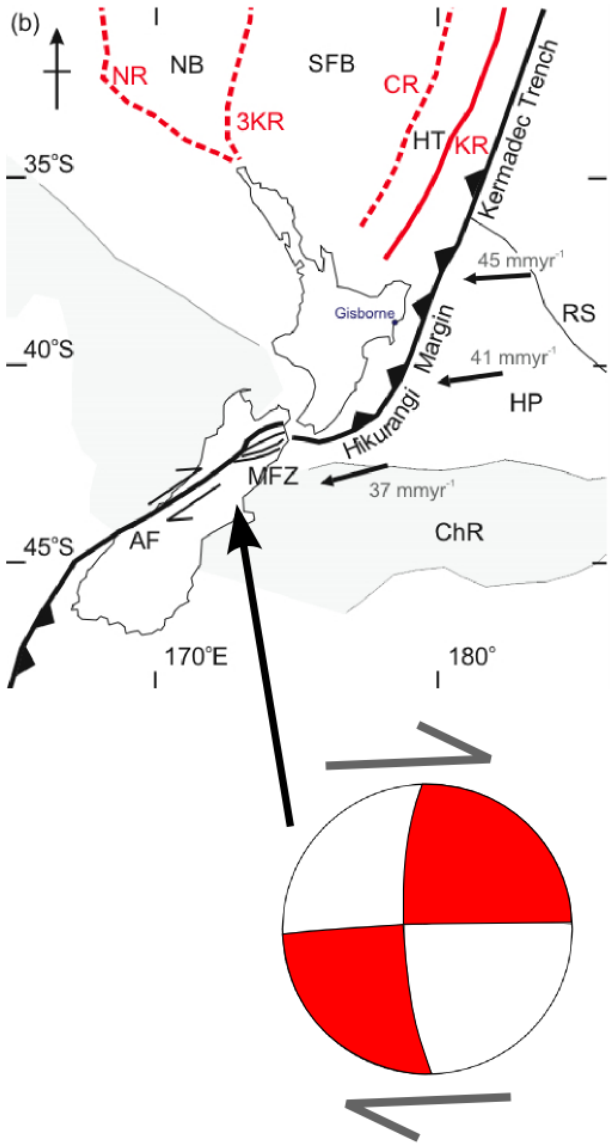
New Zealand is located at a point where the nature of the Pacific and Australian plate boundary changes in some rather fundamental ways.

The subduction zone running down the East Coast of the North Island terminates off the Northeast coast of the South Island, about 100 kilometres north of Christchurch, and gives way to a transform boundary cutting through the continental crust of the South Island, where the plate motions are accommodated by largely dextral strike-slip on the faults of the Marlborough Fault Zone (MFZ in the figure above) and the Alpine Fault (AP).

While this earthquake occurred south of the plate boundary, the focal mechanism can be interpreted as showing as right lateral strike-slip on an east-west oriented fault, suggesting that it is still linked to deformation at the plate boundary.

Source: Highly Allochthonous Blog – Chris Rowan



Focal mechanism of September 3rd earthquake, and it's location with respect to the plate boundary in New Zealand

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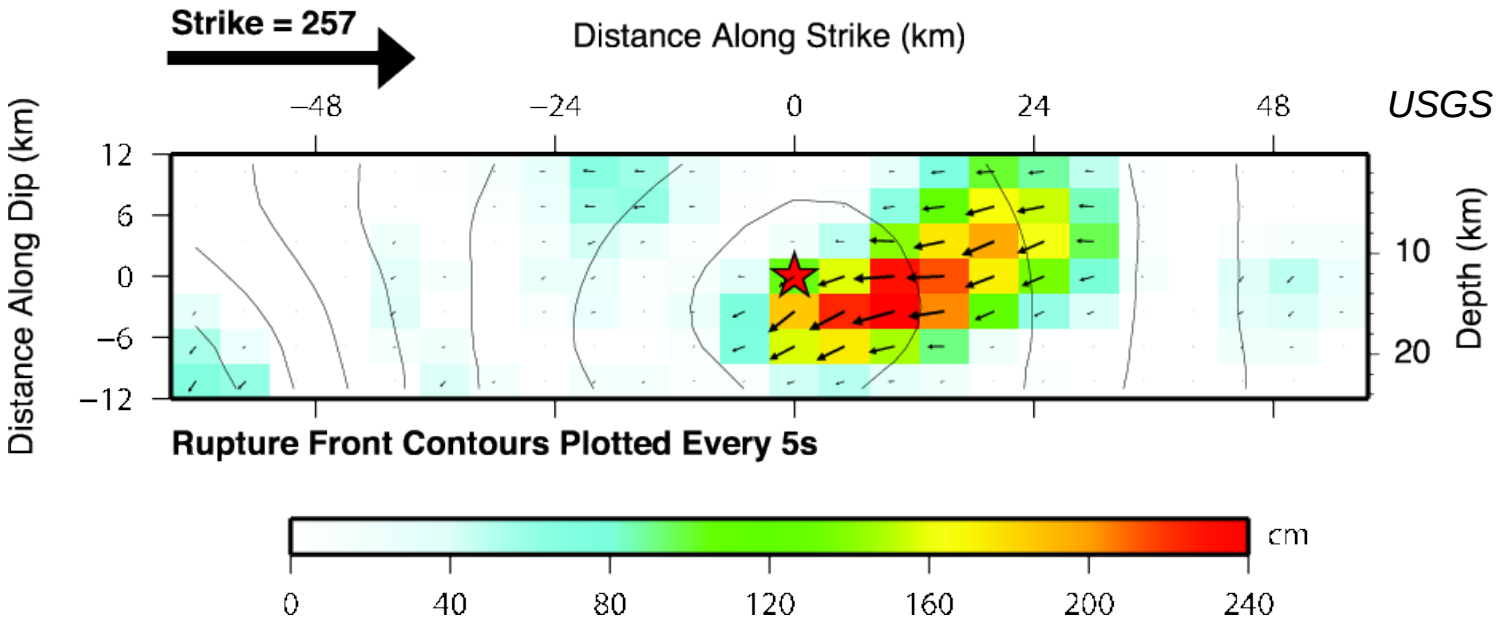

Large earthquakes involve slip on a fault surface that is progressive in both space and time.

This “map” of the slip on the fault surface of the M7.0 New Zealand earthquake shows how fault displacement propagated outward from an initial point (or focus) about 12 km beneath the Earth’s surface. This modeling is done from globally recorded seismograms

Cross-section of slip distribution. The strike direction of fault plane is indicated by the black arrow and the hypocenter location is denoted by the red star. The slip amplitude are shown in color and motion direction of the hanging wall (south side) relative to the footwall is indicated by arrows. Contours show the rupture initiation time in seconds.

Image courtesy of the US Geological Survey

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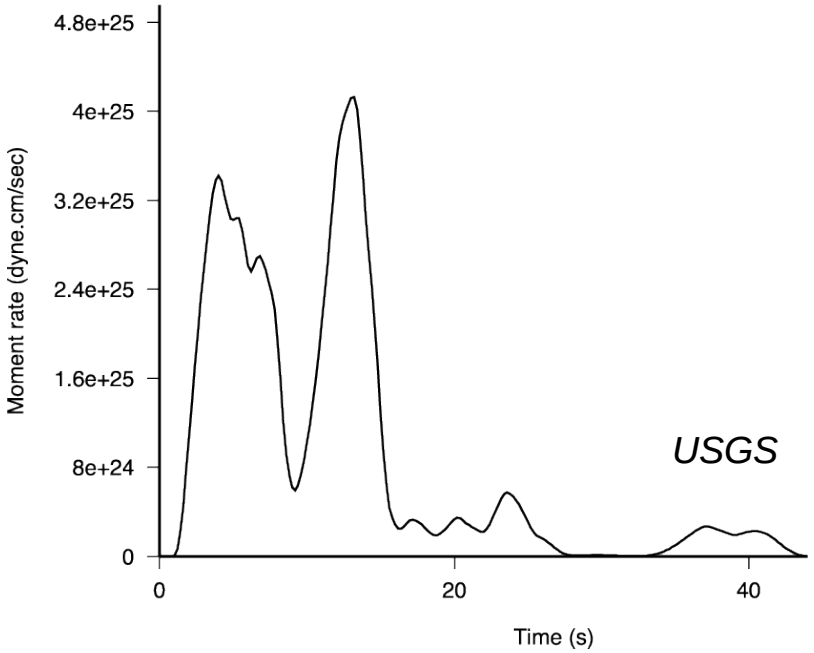
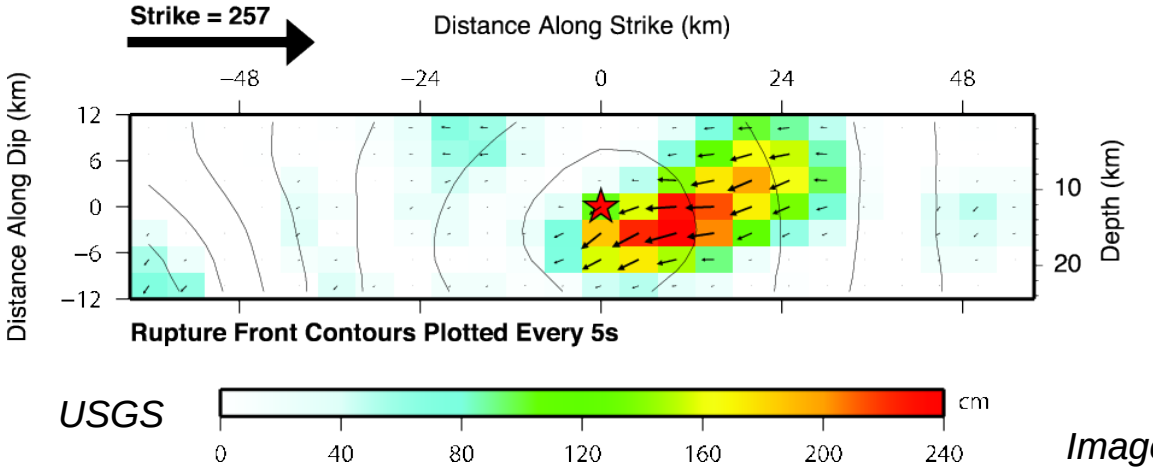
Although magnitude is still an important measure of the size of an earthquake, seismic moment is a more physically meaningful measure of earthquake size. Seismic moment is proportional to the product of the slip on the fault and the area of the fault that slips.

The largest amounts of rupture occurred within the first 20 seconds but smaller displacements continued for up to 40 seconds after the start of the earthquake.



Source time function, describing the rate of moment release with time after earthquake origin.



The fault surface has rupture front contours plotted every 5 seconds across the ~72km fault surface.

Images courtesy of the US Geological Survey

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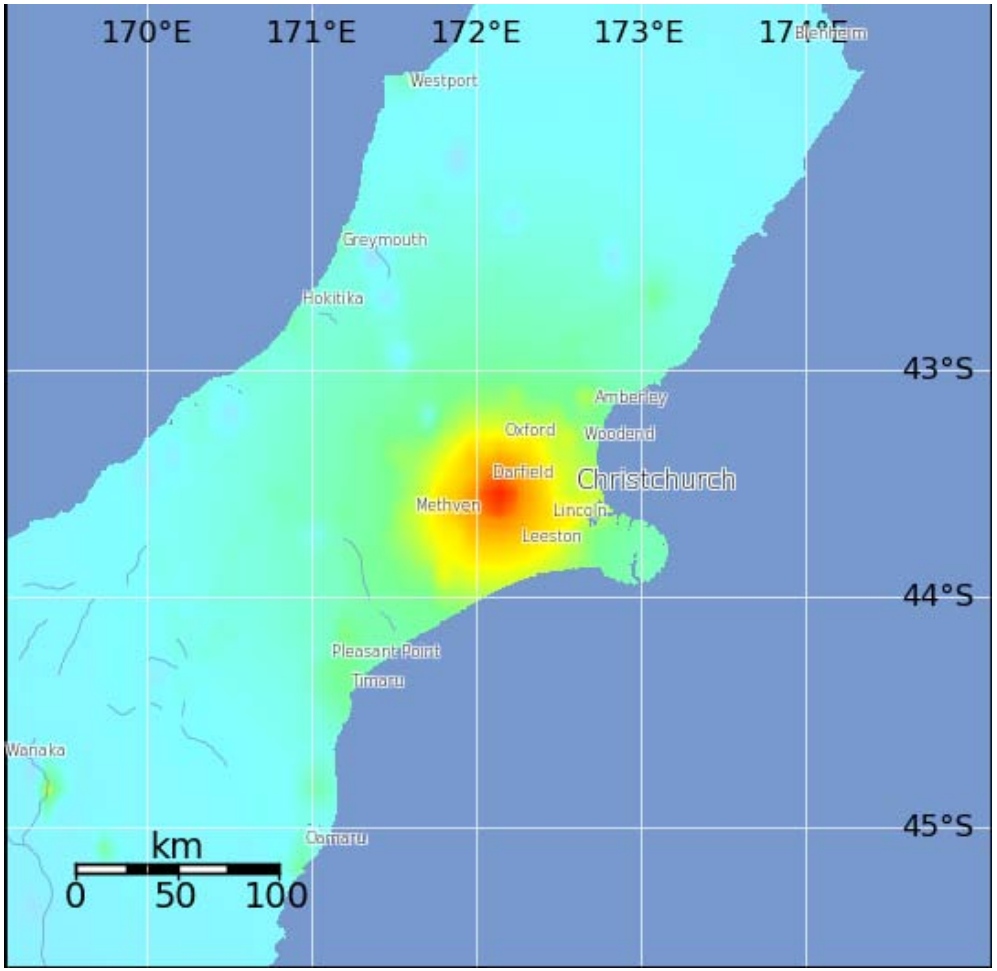
Shaking intensity scales were developed to standardize the measurements and ease comparison of different earthquakes. The Modified-Mercalli Intensity scale is a twelve-stage scale, numbered from I to XII. The lower numbers represent imperceptible shaking levels, XII represents total destruction. A value of IV indicates a level of shaking that is felt by most people.

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



USGS Estimated shaking Intensity from M7.0 Earthquake

Image courtesy of the US Geological Survey

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The New Zealand Building Code requires designers to take account of foundation conditions, and most buildings built since 1960 have been designed in the knowledge that foundation conditions will have an effect on the response of the building to earthquake forces. An assessment made by local authorities prior to this earthquake stated that some buildings could be subject to cosmetic damage in a severe earthquake but severe damage to buildings built since 1980 is not likely.

Homes in New Zealand are primarily made of wood, which withstood the earthquake. Most damage reported was due to crumbling brick from older buildings. The old masonry buildings of the city had not been designed to resist earthquakes and were prone to damage.

A building damaged by the M7.0 earthquake in central Christchurch, New Zealand.

AP Photo/NZPA, David Alexander

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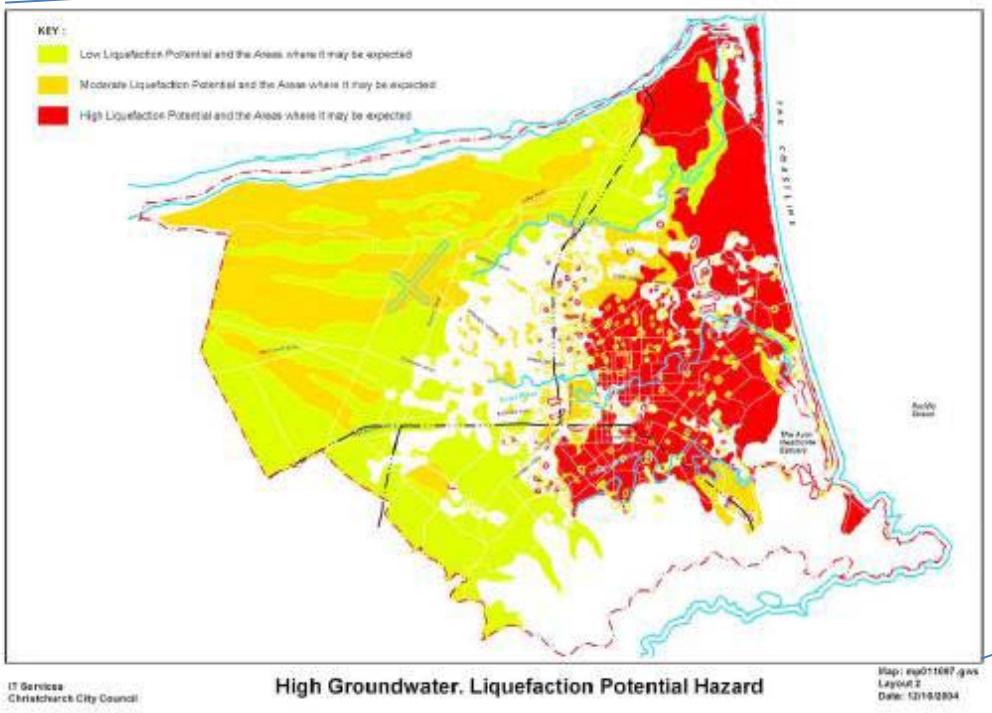
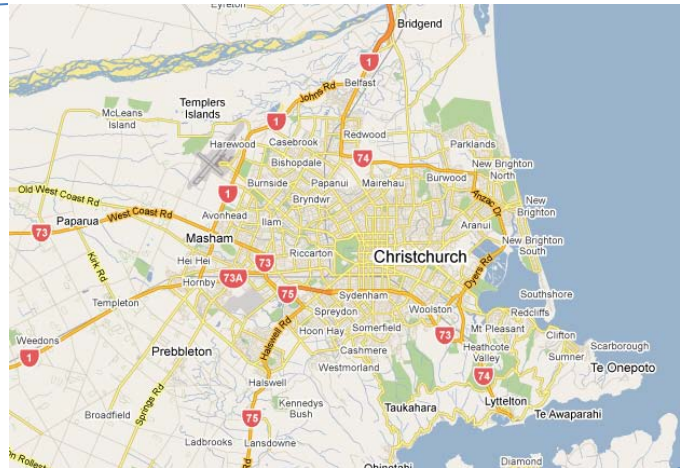


High Groundwater. Liquefaction Potential Hazard



Google Earth™ mapping service

2004 Christchurch city council evaluation of liquefaction potential hazard. (red maps high liquefaction potential)

Christchurch faces an additional hazard of liquefaction that could result from earth shaking during an earthquake.

The effects of earthquake shaking on structures vary substantially across the City, depending on local differences in landforms, soils, and ground water levels. The most susceptible areas to liquefaction are those with water saturated, loose, well soiled silt, and sand. These materials under lay large parts of the eastern suburbs, much of that section of the city sits on unconsolidated quaternary sediments.

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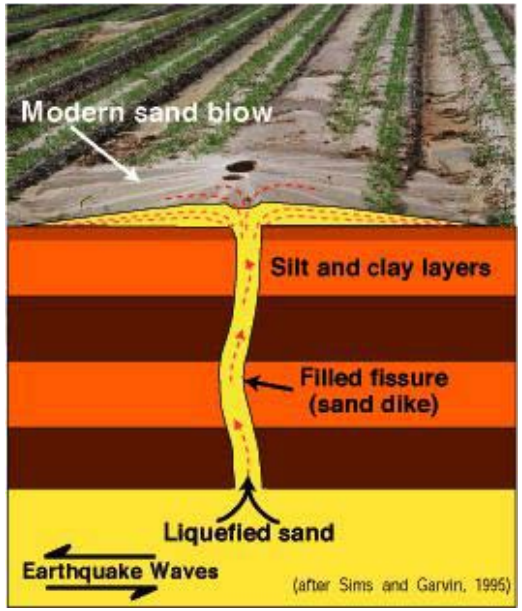
Liquefaction (where the solid ground takes on liquid qualities due to increased pressures) caused distortion of buildings and damage to buried cables, water and sewage pipes. Sand blows are characteristic evidence that liquefaction has occurred.

Imagine a cube full of sand and water. If you press it in from both sides (compressing and releasing it, then compressing it again), you build up what's called pore-water pressure," said Martitia Tuttle, geologist and consultant for the U.S. Geological Survey. "It's like shaking a coke can — when the pressure builds up and you release it, the fluid comes shooting to the surface."



Liquefaction occurs (and sand blows are formed) when the soft, sandy soil shakes forcing liquified sand to the surface causing heavy roads or whatever is on the surface to sink

USGS

Sand blow created during the M7.0 New Zealand Earthquake

New Zealand Herald-Photo / Georgia Galloway

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Comparing Haiti and New Zealand Earthquakes:

Similarities:

- Both strike-slip faults
- Both shallow- usually leading to increased damage (8.1 miles for Haiti, 7.5 miles for New Zealand)
- Both close to population centers (25 miles from Port-au-Prince in Haiti, 35 miles from Christchurch in New Zealand)

Differences:

- New Zealand has good construction codes, Haiti had no enforced codes
- Time of day (Haiti's earthquake occurred at 4:53 p.m. local time, many people out in the streets, exposed to falling debris. New Zealand's earthquake occurred at 4:35 a.m. local time, most people home in bed)

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Haiti M7.0

- 230,000 died
- 300,000 injured
- 1,000,000 homeless

Estimated Population Exposed to Earthquake Shaking

Est. Modified Mercalli Intensity	Est. Population Exposure	Perceived Shaking	Potential Structure Damage	
			Resistant	Vulnerable
X	2k	Extreme	V. Heavy	V. Heavy
IX	2,387k	Violent	Heavy	V. Heavy
VIII	626k	Severe	Moderate/Heavy	Heavy
VII	558k	Very Strong	Moderate	Moderate/Heavy
VI	903k	Strong	Light	Moderate
V	5,887k	Moderate	V. Light	Light
IV	7,176k*	Light	none	none
II-III	50k*	Weak	none	none
I	--*	Not Felt	none	none

**Estimated exposure only includes population within calculated shake map area*

USGS PAGER Alert Version: 9

New Zealand M7.0

- 0 died
- 2 injured
- dozens homeless

Estimated Population Exposed to Earthquake Shaking

Est. Modified Mercalli Intensity	Est. Population Exposure	Perceived Shaking	Potential Structure Damage	
			Resistant	Vulnerable
X	0	Extreme	V. Heavy	V. Heavy
IX	900	Violent	Heavy	V. Heavy
VIII	9k	Severe	Moderate/Heavy	Heavy
VII	17k	Very Strong	Moderate	Moderate/Heavy
VI	376k	Strong	Light	Moderate
V	124k	Moderate	V. Light	Light
IV	127k	Light	none	none
II-III	2k*	Weak	none	none
I	--*	Not Felt	none	none

**Estimated exposure only includes population within calculated shake map area*

USGS PAGER Alert Version: 6

Reported deaths and injuries made change.

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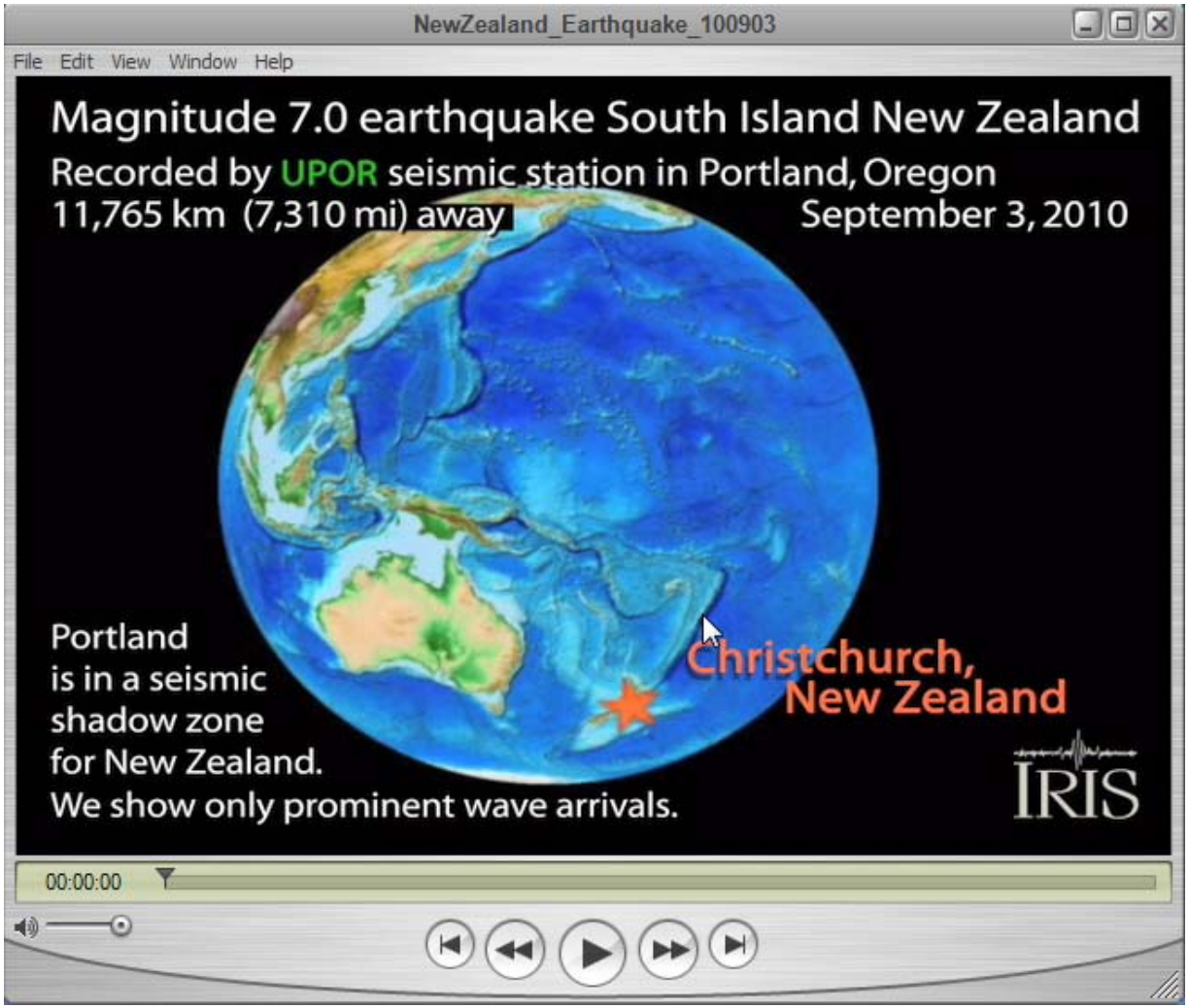
Quick Time Required

Animation of the generalized path of seismic waves traveling from the New Zealand earthquake to a seismometer in Portland, Oregon



Jenda Johnson

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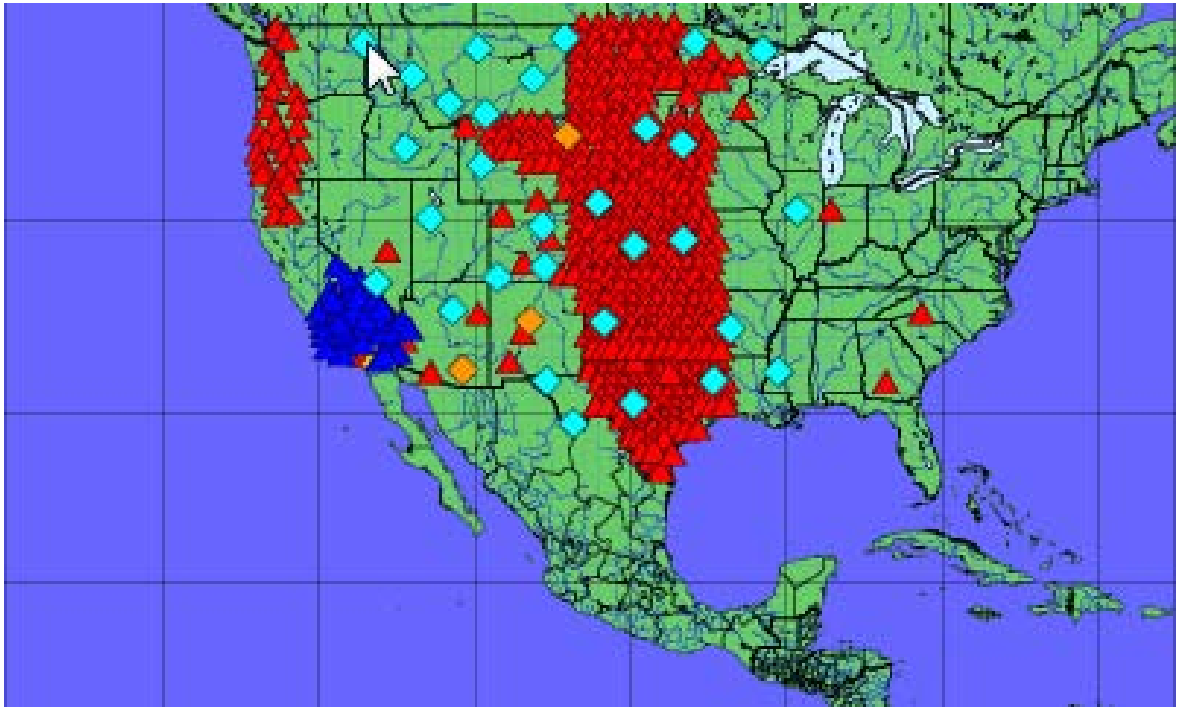
USArray: A Continental-scale Seismic Observatory

USArray's transportable array is a network of 400 high-quality broadband seismographs that are moving (every 2 years) across the United States from west to east, and Alaska, in a regular grid pattern.

These data are being used to answer questions about the United States continent and map the structure of Earth's interior.

The USArray network recorded this earthquake.



Triangle symbols are active stations at the time of the earthquake in the USArray (excluding ANSS backbone stations and GSN stations, which are represented by a diamond symbol) and colored by network. Blue lines are major rivers. Thin black lines are state boundaries and thick black lines are national boundaries.

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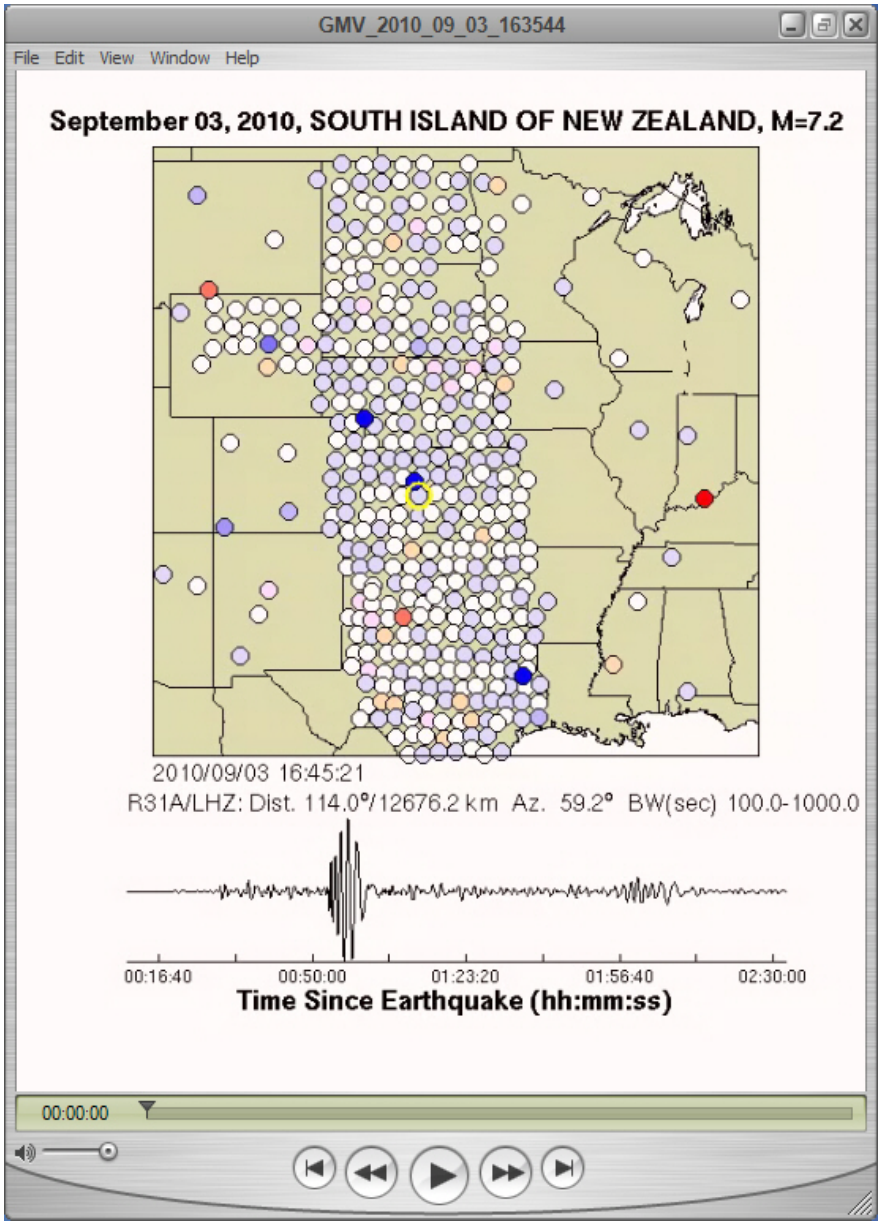
USArray Wave Visualization

This animation illustrates how seismic waves from large earthquakes sweep across this array by depicting the recorded wave amplitudes at each seismometer location using colored circles. The color of each circle represents the amplitude of the ground motion as detected by the station's seismometer and it changes as waves of differing amplitude travel past the seismometer. Blue circles represent downward ground motion while the red circles represent upward ground motions with the darker colors indicating larger amplitudes. A random representative trace is displayed on the lower part of the animation with its horizontal axis representing the time (in seconds) after the event. Location of the representative station is marked on the map by a yellow circle.



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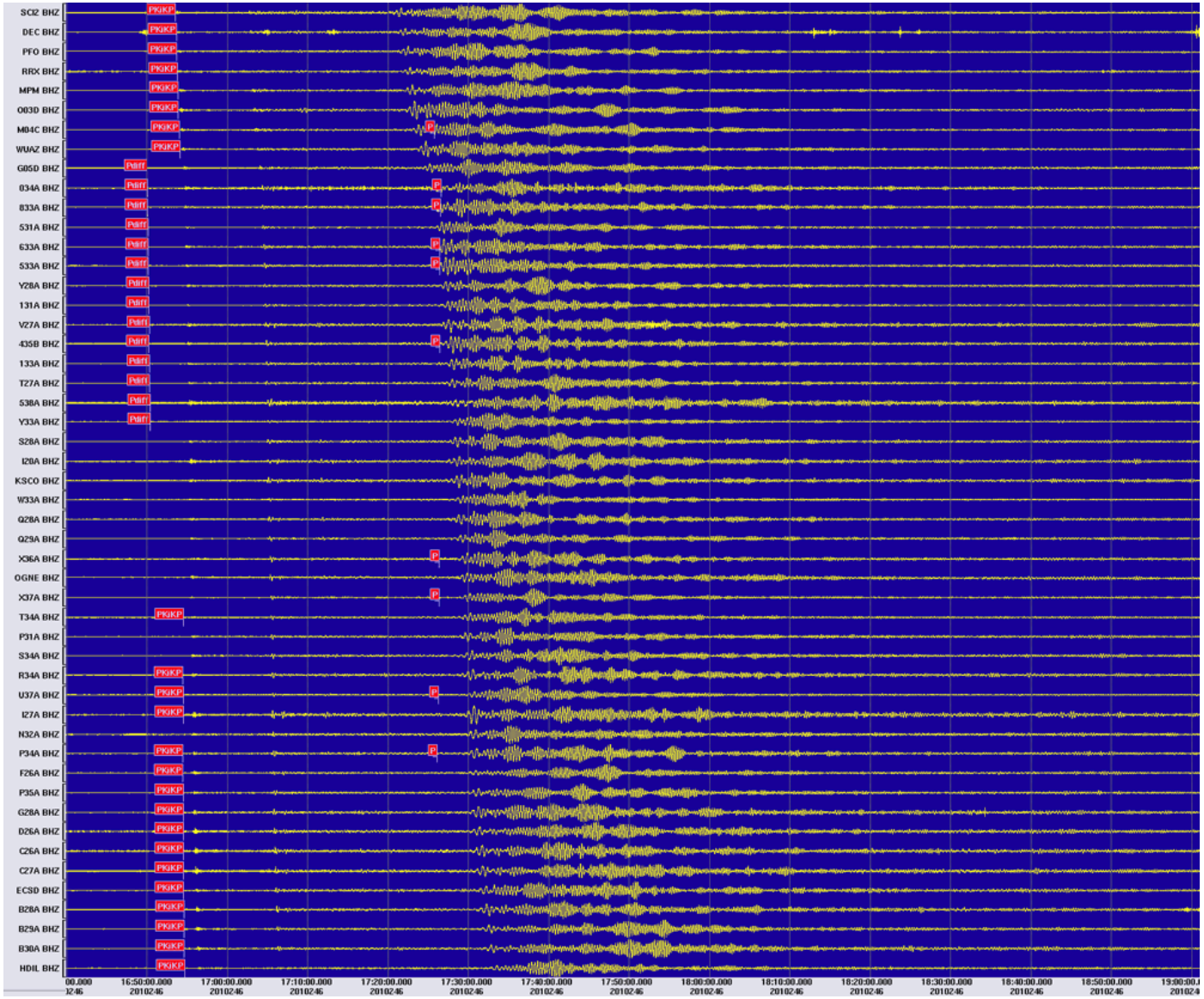

Vertical components from every eighth USArray station that recorded the event across the whole network

ANF Array Network Facility