Magnitude 7.0 Earthquake in South Island of New Zealand

Friday, September 3, 2010 at 16:35:46 UTC (10:35:46 AM Pacific Daylight Time / 05:35:46 AM Local Time)
Epicenter: Latitude 43.375°S, 172.016°E (indicated by star on map below).
Depth: 12 kilometers

As reported by the US Geological Survey National Earthquake Information Center NEIC), a major earthquake occurred Friday morning 55 km west-northwest of Christchurch in South Island of New Zealand.

Plate Tectonic Setting:

The map of the left below shows the plate tectonic setting with the epicenter of the September 3, 2010 earthquake indicated by the red star. The arrows on this map show the motion of the Pacific Plate with respect to the Australia Plate. The South Island of New Zealand is cut by a strike-slip fault, the Alpine fault, which forms the transform boundary between the Pacific and Australia plates. The green line on the left hand map shows the location of this transform boundary that is shown in more detail on the right hand map. 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 India – Australia Plate.

Historical Seismicity:

The map on the right below shows historic seismicity near the epicenter that is indicated by the orange star. In their book *Caught in the Crunch*, Rebecca Ansell and John Taber describe the relative earthquake risk to Christchurch: “The nation’s capital, Wellington, is the New Zealand city most likely to be struck by the next large earthquake. … Christchurch is not far behind Wellington in the earthquake sweepstakes. Although the chances of a catastrophic quake occurring here are much less, for moderate-sized earthquakes that could cause significant damage and possible loss of life, the risk is almost as high as Wellington’s. Christchurch is also at risk from large but distant earthquakes on the Alpine and Hope Faults, which are the two fastest-moving onshore faults in New Zealand.”

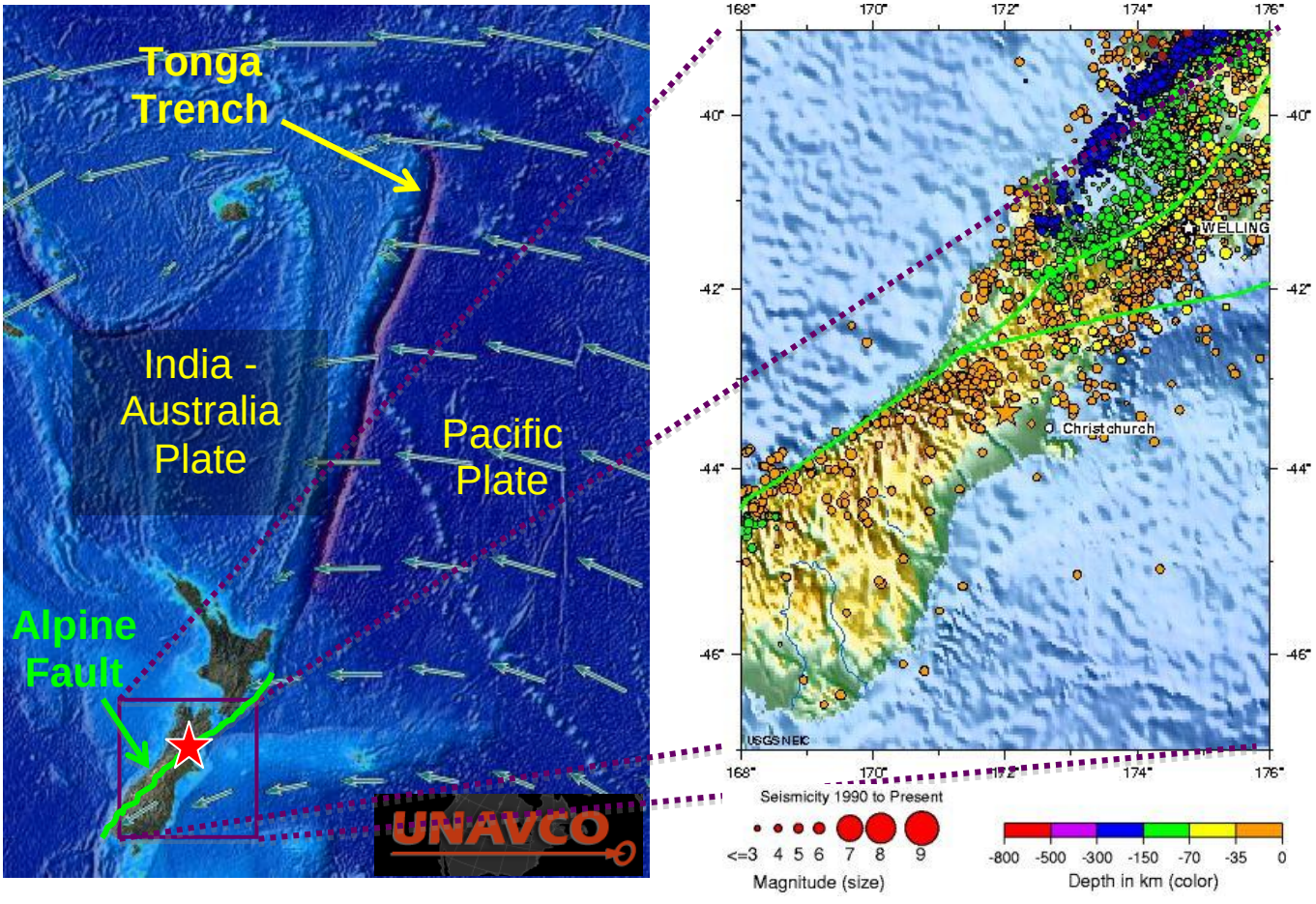

image courtesy of the US Geological Survey

Seismogram Description:

The record of the New Zealand earthquake on the University of Portland seismometer is illustrated below. Portland is about 11,722 km (~7284 miles, 105.6 degrees) from the location of this earthquake. Body waves travel through Earth's mantle from the earthquake to a distant station along paths that curve upwards because the velocity of seismic waves generally increases with depth in the mantle. However, direct P and S waves cannot travel to stations more than epicentral distance $\Delta > 103°$ because of the large decrease in wave velocities across the boundary between the mantle and the liquid outer core. (Epicentral distance, Δ, is the angle formed by the intersection of the line from the earthquake to Earth's center with the line from the observing point to the Earth's center.) There is a "shadow zone" for direct P waves in the range $103° < \Delta < 143°$. The S-wave shadow zone exists for $\Delta > 103°$ because the liquid outer core blocks S waves that cannot travel through liquids. The first arrival to Portland is a diffracted P wave, which travels through the mantle and is diffracted off the mantle – core boundary. It is recorded in Portland about 14 minutes 9 seconds after the earthquake. It is the first arrival marked on the seismogram below.

The second arrival marked on the seismogram below is actually two waves arriving to the station at the same time. The PP arrival is a compressive wave that traveled through Earth's mantle and bounced midway between the epicenter and Portland; PKiKP is a wave that travels a path ultimately bouncing off the outer core – inner core boundary before traveling back out to the station. These waves both arrive to the station about 18 minutes 31 seconds after the earthquake.

The third marked arrival is a Sdiff, a diffracted S wave that diffracted off the mantle – core boundary following the same path as the Pdiff wave. This wave arrives to the station about 26 minutes 4 seconds after the earthquake.

The forth marked arrival is both PS and SP. The path of these waves is the same as a PP, bouncing midway between the epicenter and Portland. However, the difference is that each wave travels half the distance as an S wave, and the other half as a P wave. These arrivals arrive to Portland about 27 minutes 46 seconds after the earthquake.

The (Love and Rayleigh) surface waves traveled from the earthquake to Portland around the perimeter of the Earth. Because the distance around the perimeter is longer than the distance through Earth's mantle and the speed of surface waves is slower than body waves, surface waves did not arrive in Portland until about 44 minutes after the earthquake occurred.