POTENTIAL TSUNAMIGENIC EARTHQUAKES IN NEW ZEALAND

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There were aftershocks of 5.1 on September 8 and of 5.0 on October 19, 2010. Everyone thought that there was no sense of urgency about future events. This was especially painful when the Canterbury Television building collapsed in the February event killing 115. There were two additional effects here - a communications hub was destroyed and the wreckage was a very visible reminder of loss. Subsequently, there was a swarm of earthquakes on December 26, 2010 and on January 21 there was another event described as an aftershock of 5.1 Richter. However, this event was too strong and too far in space and time to be considered as an aftershock. Also, a stronger event of about 6.5 was anticipated and if it occurred close enough to the coast and the constricted waters near Wellington (or even offshore) whether it would be capable to generate a local tsunami.

The progression of recent earthquakes in the region, indicates energy transfer to adjacent faults. More earthquakes with local tsunamigenic potential can be expected near South Island with additional adverse impact in the Christchurch and perhaps the in the Wellington area o North Island. Several of the faults that may be present in the area have not been adequately identifie As recently as September 1, 2016, a magnitude 7.2 earthquake occurred off the east coast of North Island. However this quake had a deep focal depth of 99 miles, thus did not pose a threat of tsunami generation or of damage from surface seismic waves It is believed that another large earthquake similar to the 21 February 2011 event will occur in the near future in New Zealand, perhaps slightly north-west of the 2011 Christchurch event with a magnitude which may range around 6-6.5.
Given the nature of the geology of New Zealand, earthquakes along the plate boundary are common, although those of magnitude 7.0 or more are relatively infrequent. The largest recorded earthquake in New Zealand took place in 1855 at Wairapa and had a magnitude of 8.2. Earthquakes of 7.8 magnitude have caused significant damage and some loss of life in 1931, 1929

and 1848. More recently, in July 2009 an earthquake of M7.8 occurred in the South Island's relatively uninhabited west coast re Since the region is part of a complex broad plate boundary, the seismicity is relatively low.
Because of its proximity to the Alpine fault and the continuous, interactive and large tectonic movements along this great seismic boundary, more earthquakes can be expected.

The present study reviews the seismicity of the region and the potential for tsunamigenic earthquakes in the New Zealand regio

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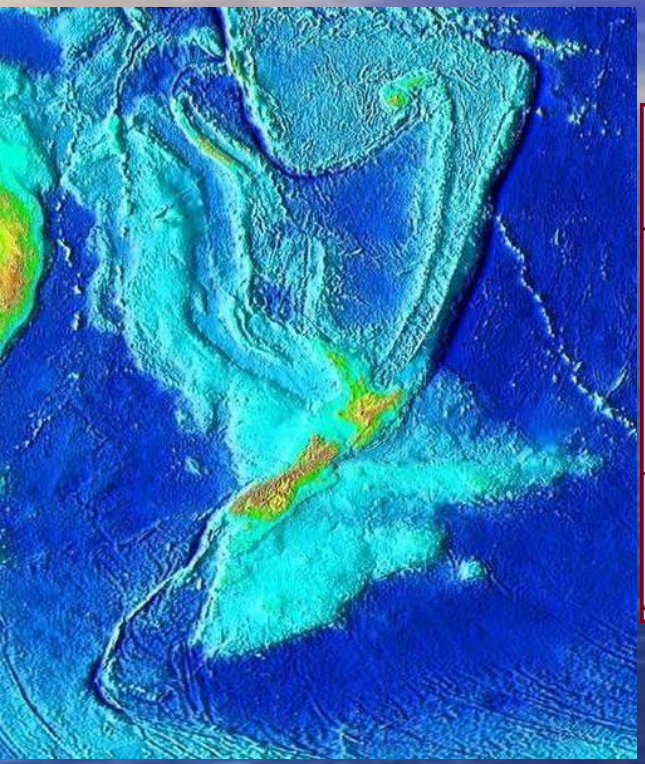

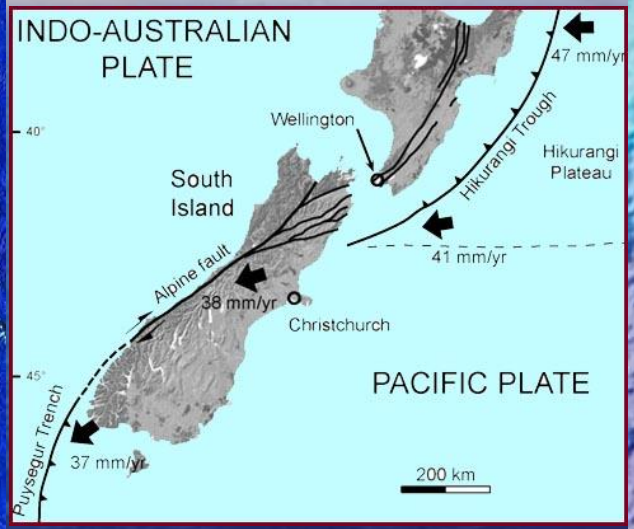

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and 1848. More recently, in July 2009 an earthquake of M7.8 occurred in the South Island's relatively uninhabited west coast region; while the broader region of Canterbury Province experienced major earthquake events in 1929 and 1888. In more modern times, the Canterbury area has been shaken by quakes of M5.9 and M6.7 in 1994. Prehistoric tsunamis have occurred in New Zealand from cascading nuee ardente and pyroclastic volcani flows
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PREVIOUS LARGE EARTHQUAKES IN NEW ZEALAND

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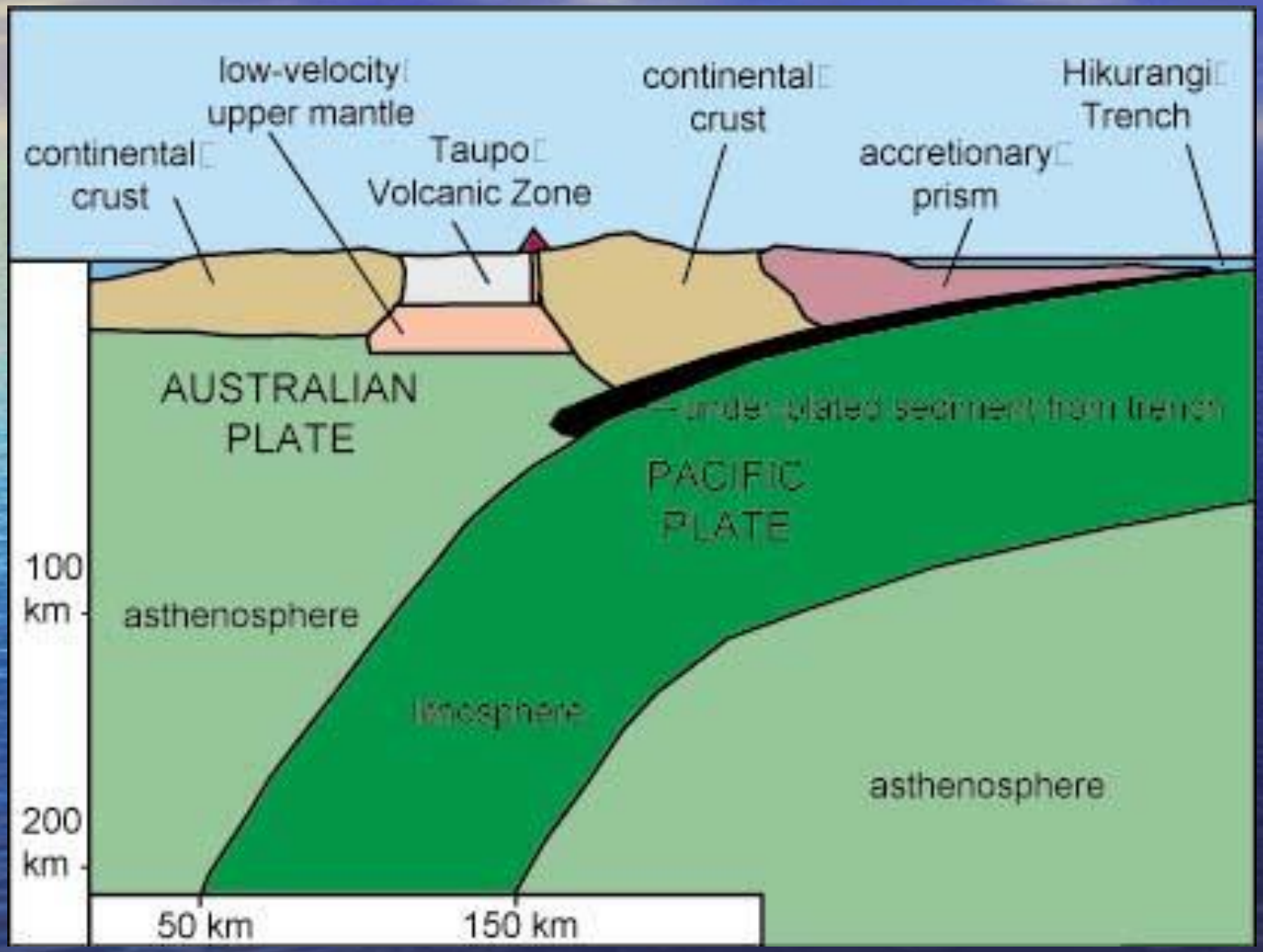
2010 SEPTEMBER 4 - A severe earthquake struck near the city of Christchurch, in the South Island of New Zealand. The earthquake had a magnitude of 7.0 (USGS) making it one of the largest to occur in 2010. No fatalities were reported but there was considerable damage to buildings in and around Christchurch. –
The Christchurch Earthquake of 4 September 2010 The epicentre of the earthquake was between 40-50 km west Christchurch (sources vary) and was followed by a number of aftershocks. At the time of writing at least thirty had been recorded which registered a magnitude of at least 4.0: the aftershocks to continued for a period of days or weeks and caused further damage Although details of the earthquake's magnitude, physical causes and mechanisms remain to be confirmed, it appears that it took place along one of the two major faults, the Hope Fault and the Alpine Faults, which run along the South Island and are the main expression of the boundary between the Pacific and Indian (or Indo-Australian) plates

NOVEMBER 22 - A 7.1 magnitude earthquake of relatively shallow depth occurred o off the west coast of South Island (NEIC).- This earthquake occurred on Monday, November 22, 2004 at 20:26:23 UTC and had a magnitude 7.1. (NEIC)

1979 OCTOBER 12 - A thrust earthquake with magnitude 7.3 occurred near the Puysegur trench.

PREVIOUS LARGE EARTHQUAKES IN NEW ZEALAND



The earthquake of February 22, 2011 in New Zealand

It occurred at the Canterbury Plains near the city of Christchurch. The seismic region where this earthquake occurred includes the southwest part of South Island (known as Fiordland) and extends offshore to the southwest covering the adjacent Puysegur Trench, which marks the tectonic boundary where the Pacific and Australian plates collide.
Although the earthquake's magnitude was only 6.3, it was extremely destructive. Five months earlier, in September 2010, a stronger earthquake had struck 40 kilometres west of Christchurch, near the town of Darfield, but did not cause significant damage.

DATE AND TIME - 23:51 on 21Feb 2011 UTC (12:51, 22 Feb 2011 NZDT local time and date).
MAGNITUDE - 6.3
DAMAGE AND CASUALTIES - There was severe destruction to the city of Christchurch.

FOCAL MECHANISM
Shallow rupture. Its focal mechanism indicates that it was mainly a strike-slip event.
AFTERSHOCKS - There were many strong aftershocks following the main earthquake. Two stong aftershocks occurred on Monday, June 13th, nearly four months after the 21 February main quake. According to USGS data, the first was a shallow event with depths of 11 km and had magnitude of 5.2 and epicenter about 9 km (5 miles) east-southeast of Christchurch.
The second quake occurred 90 minutes later. It was also shallow (focal depth 9km) and had a magnitude of 6.0. Its epicenter was - about 13 kilometers (8 miles) north-northeast of the city.

NO OPEN COAST TSUNAMI WAS GENERATED
The earthquake occurred onshore, so there was no tsunami generated. Loss of power at the tide gauge of Lyttelton Port of Christchurch failed to record any wave activity. The GeoNet site at Sumner Head, which is located on the open coast

,registered some longer period waves but these were the result of weather related generation and not of seismic origin.
Glacial Tsunami Generated - According to eyewintesses the earthquake's motions were mild in Aoraki Mt. Cook National Park on the western side of New Zealand's South Island. However the shaking triggered a break of 30 million tons of ice off the end of the Tasman Glacier. The eyewitnesses stated that the icefall generated an initial wall of water that was 50 or 60 meters high and that 10-foot-high tsunami waves washed ashore along the shores of the Tasman's glacial lake.

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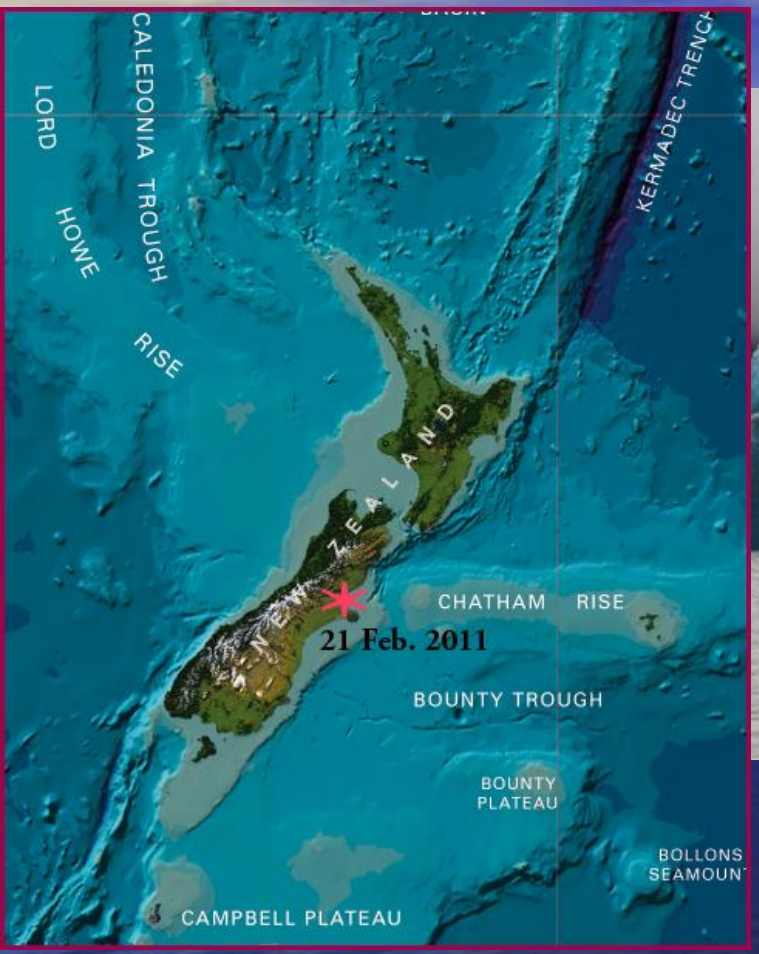

NEW ZEALAND SEISMICITY

New Zealand's proximity to active boundaries of the Pacific and Australian tectonic plates accounts for its high seismicity. The historical record indicates that in the last 200 years both North and South Islands have experienced several earthquakes with magnitudes greater than 5.

North Island is part of the Australian continental plate which is underthrusted by the higher density Pacific Oceanic plate along a zone of subduction. Something similar is occurring to the south-west of South Island. But here the sliver of continental crust lies on the Pacific plate, and it is the Australian plate that is being destroyed through subduction.

In between, the continental crust on the Pacific and Australian plates slide past one another on South Island, creating a conservative plate margin where crust is neither created nor destroyed. This area is still prone to earthquakes, most notably along the Alpine fault. Further away from these fault zones the ground is generally more quiescent.
Christchurch is over 100 kilometres from the Alpine fault.
So what caused the Christchurch quake? It was caused by a new fault – or, to be more precise, a previously unrecognised fault.

"The fault is likely to have existed previously – and possibly produced earthquakes before – but they have not ruptured recently.
The unrecognised fault appears to be an offshoot from the Alpine fault.
Are more quakes on the fault are very likely to occur. Some stress has been released but more stress remains in the region.

The rocks on either side of the Alpine fault are grinding past each other quickly – at around 30 millimetres per year.
The southern part of South Island has moved at least 480 kilometres relative to the northern part within the past 25 million years. That rate of movement is great – and not far off the displacement seen on the world-famous San Andreas fault in California, which is itself a conservative plate margin.

Fast forward several million years and New Zealand will continue to twist and turn. The activity that is already shredding the country will ultimately see South Island split in two along the Alpine boundary.

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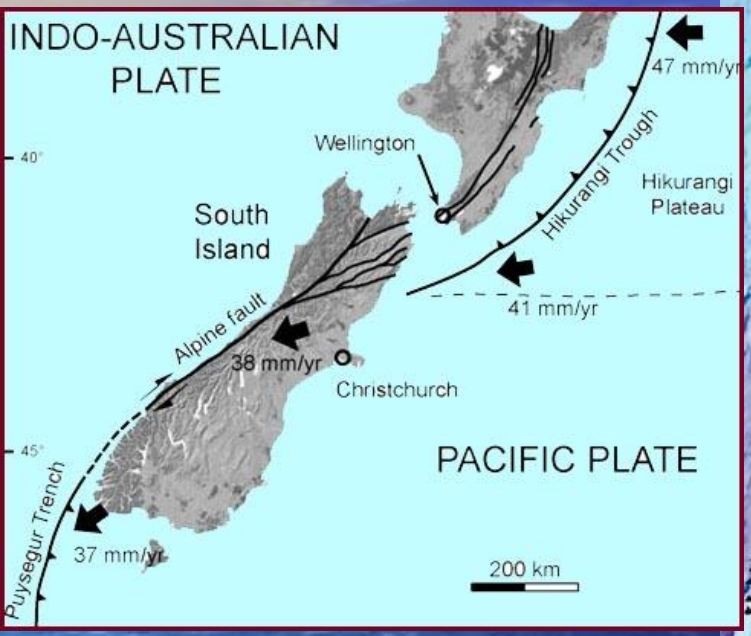

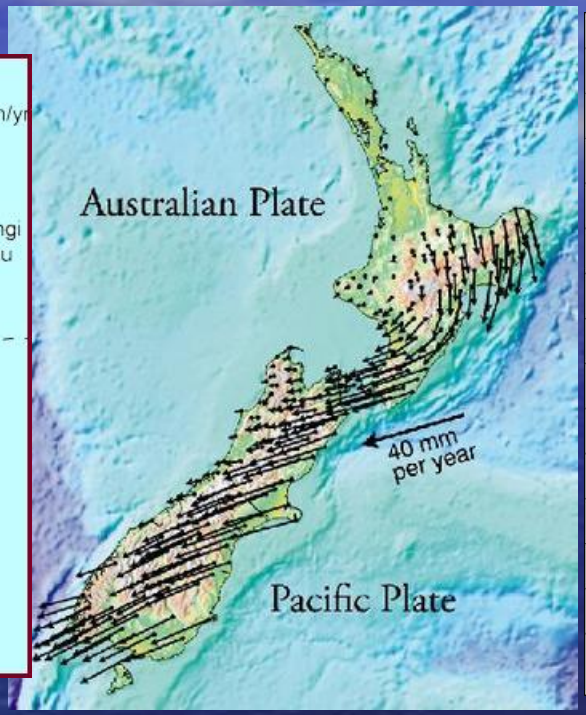

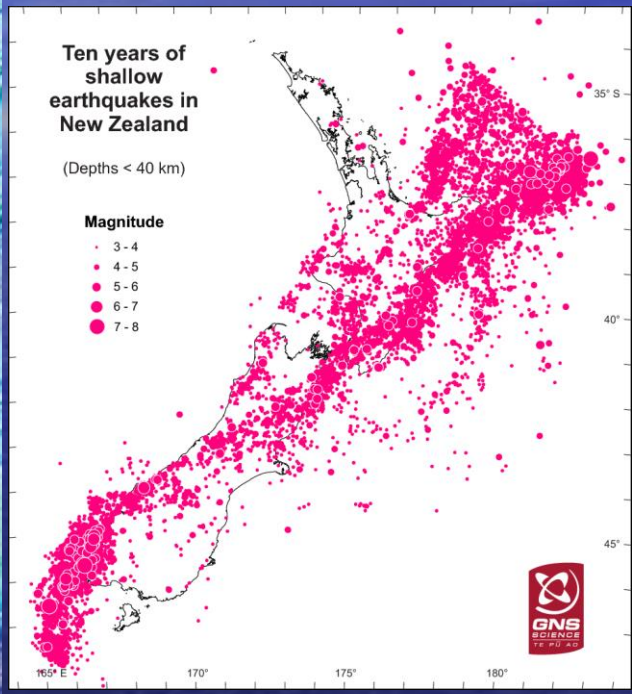

NEW ZEALAND's TECTONIC SETTING

New Zealand is part of a largely submerged microcontinent in the South Pacific Ocean. It has two main islands, North Island and South Island. These islands straddle the boundary between the Pacific and Australian tectonic plates and are undergoing a gradual elongation and compression, due to the continuous 4 cm/year northeastwards motion of the Australian plate relative to the Pacific plate.

Along New Zealand, the plate boundary consists of a transform fault system connecting two subduction zones of opposing convergent directions that lie to the north and south of South Island.

Oblique subduction of the Australian plate underneath the Pacific plate occurs along the Puysegur trench. The subducted plate is moderately dipping in the south part of the trench and further to the north a gradual change in strike of 17 degrees

accompanies a steepening in dip of the slab to near vertical below Fiordland. The exact age and mechanism of this young subduction zone is presently being debated . Off the south coast of Fiordland active subduction at the Puysegur Trench produces earthquakes in several areas including: within the subducting Australian plate, in the overlying Pacific plate, and at the interface between the plates. The earthquake occurred to the west of the trench in the Australian plate.

There are many fault systems in the region and the USGS is not certain of the particular fault responsible for this recent earthquake.

Although Fiordland is sparsely populated some earthquakes in this region are felt by people throughout the South Island, such as the magnitude 7.2 thrust earthquake of August 21st 2003. People felt this event as far north as Wellington on North Island and Sydney, Australia.

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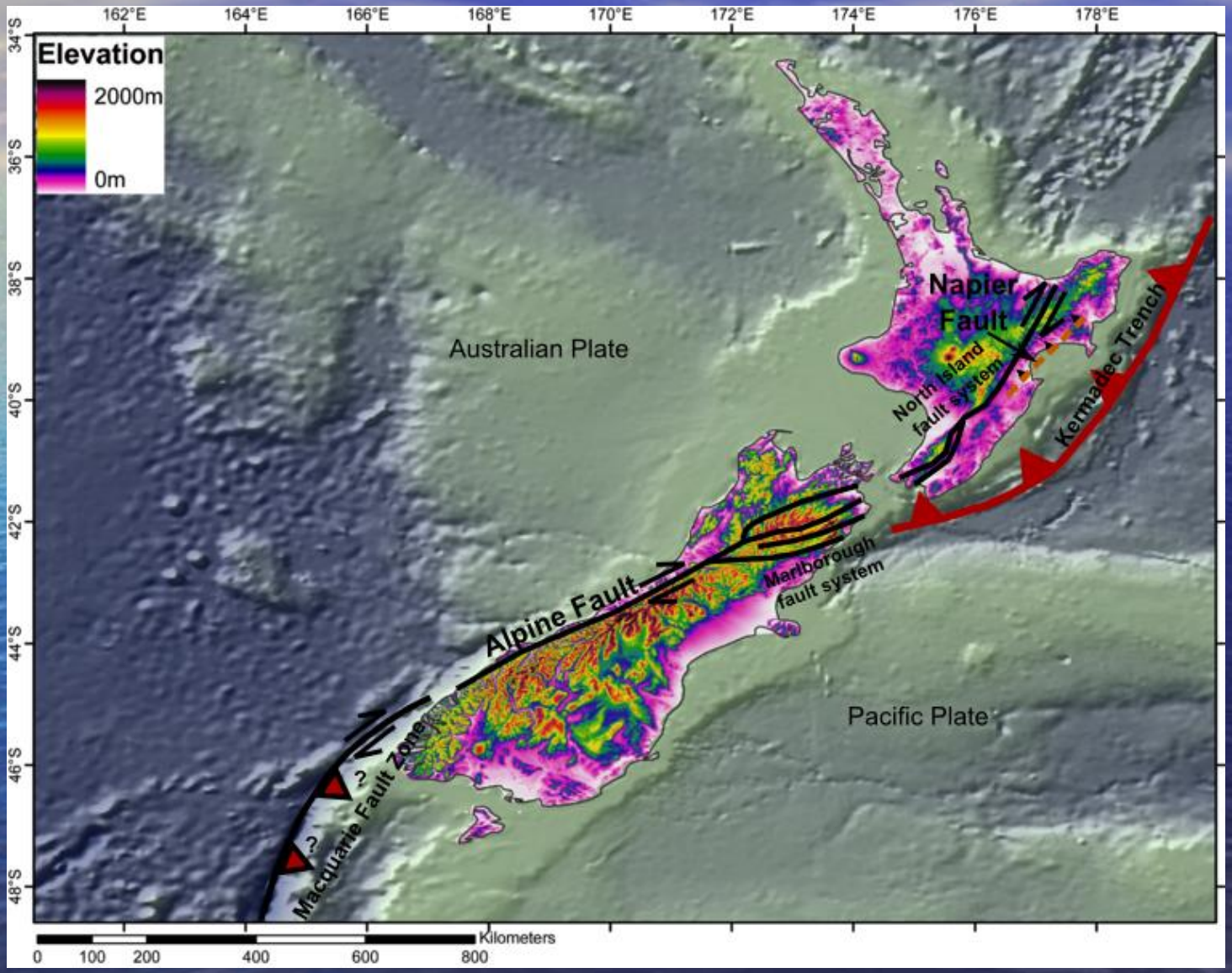

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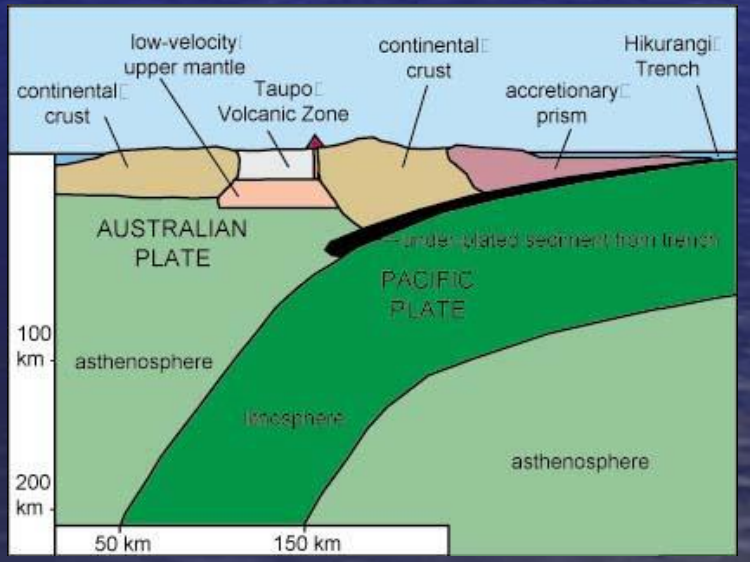

REMAINING STRESS

Not all the stress has been released in the New Zealand region and more earthquakes can be expected on land and offshore of both North and South Islands.

tectonic evolution is ongoing, and since the end of the subduction zone is now actually to the south of the southernmost and youngest of the Marlborough faults.

Some of the plate boundary deformation continues to occur in the region around Christchurch.
Large historic earthquakes indicate that they can occur again anywhere in New Zealand, and could be particularly damaging regions of unconsolidated Quaternary sediments, like in Crjstchurch - which will intensify the potential shaking and damage to unreinforced buildings.


THANK YOU