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CANTERBURY DISASTER SALVAGE TEAM
"Working Towards Saving Cultural Collections"

NEWSLETTER

Number 32 **September 2005** **Cynthia Cripps, Editor**

Contents

Earthquakes!

Introduction

Most emergency / disaster response references for the heritage community focus on those issues relating to safety, mitigation and recovery of collections and rightly so as this is all extremely important information. However, when it comes to earthquakes, what is sometimes neglected is the information needed to understand the underlying mechanisms the cause the event and the terminology used by professionals to describe it. Aside from being interesting information, knowing more about earthquakes can help when trying to understand what the experts are saying and with developing effective safety, mitigation and response measures for heritage collections and human safety

The following is a sample of the information available from various science websites[1].

Earthquake Basics

Earthquakes occur when the tension between two sections along a fault or two plates is suddenly released and the resulting seismic waves make the ground shake.

Earthquakes are happening constantly all over the world along faults or plate edges.

Faults
Cracks in the earth where sections of a plate (or two plates) are moving in different directions. Faults are caused by plate movements and are more common near the edges of the plates. As far as seismologists understand, all but the very deepest earthquakes (deeper than 600km) occur on faults.

Types of Faults

- *Normal faults*: where one section is sliding downward and away from another. These usually occur where a plate is very slowly splitting apart or two plates are pulling away from each other.
- *Strike-slip faults*: between two plates that are sliding past each other.
- *Reverse faults*: formed where one plate is pushing into another plate or a plate is folding up due to compression from another plate. Either one section slides underneath another or one section is pushed up over the other.

[1] Listed at the end of this article.

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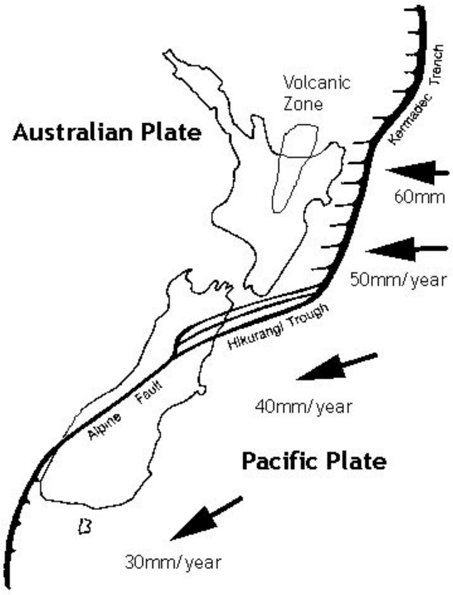
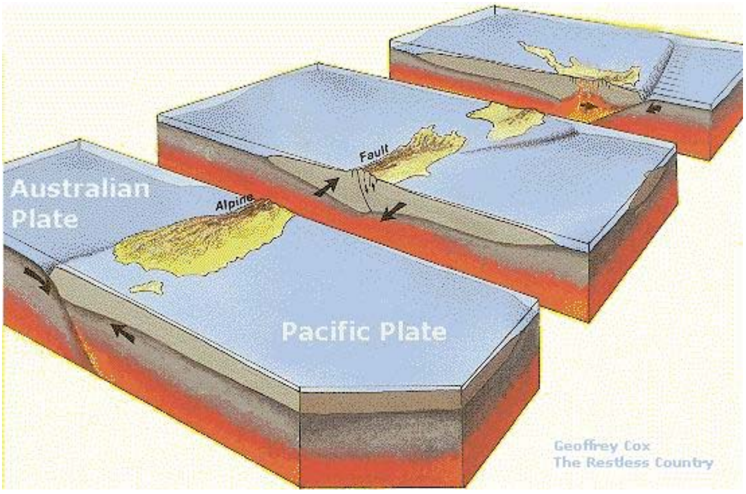
Plates
There are two types: oceanic and continental and they move in response to the motion of the mantle layer beneath. This movement results in plates to bumping into each other, moving away from each other, or sliding past each other.

Plates in New Zealand





The plate junction is very complex in New Zealand:

- Along the alpine fault (South Island) the plates are sliding past each other
- North, the Australian plate rides over the Pacific plate. (Kermadec trench)
- South, the Pacific plate rides over the Australian plate. (Macquarie ridge)
- In the volcanic triangle of the North Island, the country is tearing apart, creating the East Cape in the process.

Significant New Zealand Earthquakes Since 1848

		Magnitude			Magnitude
16 October 1848	Marlborough	7.5	3 February 1931	Hawke's Bay	7.8
23 January 1855	Wairarapa	8.1	13 February 1931	Hawke's Bay	7.3
23 February 1863	Hawke's Bay	7.5	5 March 1934	Pahiatua	7.6
19 October 1868	Cape Farewell	7.5	24 June 1942	Wairarapa	7.2
1 September 1888	North Canterbury	7.3	2 August 1942	Wairarapa	7.0
12 February 1893	Nelson	6.9	24 May 1968	Inangahua	7.1
9 March 1929	Arthur's Pass	7.1	6 February 1995	East Cape	7.0
17 June 1929	Murchison	7.8	22 August 2003	Fiordland	7.1

Earthquakes Hazards

Ground Shaking
Structures may be damaged either by the shaking itself or from the ground underneath settling to a different level (subsidence). Strong surface waves make the ground heave and lurch and any buildings in the path of these waves may lean or tip over from the movement.

Soil liquefaction, the mixing of sand or soil and groundwater, may also occur. The ground becomes very soft and similar to quicksand. Buildings may start to lean, tip over, or sink several feet. Once the earthquake is over, the water settles back down to a deeper level and the ground solidifies. Liquefaction is a hazard in areas that have groundwater near the surface and sandy soil.

The ground shaking may also cause landslides, mudslides, and avalanches on steeper hills or mountains, all of which can damage buildings and hurt people.

Ground Displacement
Ground movement along a fault. If a structure is built across a fault, ground displacement can cause serious damage.

Flooding
Cause by:

- dams or levees along a river are ruptured
- a tsunami from an earthquake under the ocean
- a seiche, small tsunamis that occur on lakes shaken by the earthquake

Fire
As a result of broken gas lines and power lines, or tipped over wood / coal stoves.

Predicting Earthquakes
It is possible to estimate where big earthquakes are likely to occur in the next 50 to 100 years (based on geological investigations and the historical record of earthquakes), but it is still not possible to accurately predict when and where they will occur in the short term.

Measuring Earthquakes

The Richter Scale
A magnitude scale to express the seismic energy released by each earthquake and was developed by Dr. Charles Richter during the 1950s in California, USA.

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5 to 4.9	Often felt, but rarely causes damage. Some shaking of indoor items.
5.0 to 5.9	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.0 to 6.9	Can be destructive in areas up to about 100 kilometers across.
7.0 to 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Intensity
Although each earthquake has a unique magnitude, its effects will vary greatly according to distance, ground conditions, construction standards, and other factors. Seismologists use intensity to estimate the effects of an earthquake. Intensity measures the relative earthquake effects and is variable from place to place depending on:

- building designs,
- distance from the epicenter,
- the type of surface material (rock or dirt) the buildings rest on

For example, solid rock usually shakes less than sand, so a building built on top of rock shouldn't be as damaged as it might if it was sitting on a sandy lot.

Terms / Definitions

Seismology: the study of earthquakes and seismic waves that move through and around the earth.

Seismologist: a scientist who studies earthquakes and seismic waves.

Seismic waves: waves of energy caused by the sudden breaking of rock within the earth. They are the energy that travels through the earth and is recorded on seismographs.

Body Waves: seismic waves that travel through the earth's inner layers.

Surface Waves: seismic waves that can only move along the surface of the planet.

Primary (P) Wave: a type of body wave and the fastest kind of seismic wave. The P wave can move through solid rock and fluids. This wave causes compression and dilation of rock.

Secondary (S) Wave: a type of body wave, and the second wave felt in an earthquake. An S wave is slower than a P wave and can only move through solid rock. The S wave moves rock up and down, or side-to-side

Love Waves: a type of surface wave and named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. It's the fastest surface wave and moves the ground from side-to-side.

Rayleigh Waves: a type of surface wave and named for John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. A Rayleigh wave rolls along the ground, moving it up and down and side-to-side. Most of the shaking felt from an earthquake is due to the Rayleigh wave which can be much larger than the other waves.

Hypocenter: the location beneath the earth's surface where the rupture of the fault begins.

Epicenter: the location directly above the hypocenter on the surface of the earth.

Magnitude: a measured value of the earthquake size. The magnitude is the same no matter how strong or weak the shaking was in various locations.

Intensity: is a measure of the shaking created by the earthquake and varies with location.

Free oscillation of the Earth: "Ringing like a bell" from the most powerful earthquakes. Seismic waves travel all around the Earth after a very powerful earthquake and can last for days.

Foreshocks: earthquakes that occur up to days or weeks prior to a larger earthquake.

Aftershocks: earthquakes that occur following the main earthquake event.

Websites

Where It Get Information On Hazards In Your Area

- Geological and Nuclear Sciences webpage with great maps of fault lines etc. http://maps.gns.cri.nz/website/af/
- Local councils (city and regional webpage listing) http://www.localcouncils.govt.nz/lgip.nsf/wpg_url/Councils-A-Z-Councils-by-Region-Index)
- Civil Defence (through councils or Ministry of Civil Defence http://www.mcdem.govt.nz/memwebsite.nsf)

Other

- GeoNet – shows recent earthquakes in NZ and volcano status http://www.geonet.org.nz/
- Victoria University – School of Architecture – Earthquake hazard Centre (EHC) http://www.vuw.ac.nz/architecture/research/ehc/index.aspx. Contains news and information to upgrade earthquake design and construction practice. The EHC is a non-profit organisation supported by Robinson Seismic Ltd and the New Zealand Ministry of Civil Defence and Emergency Management. It is based at the School of Architecture, Victoria University of Wellington, NZ.
- Earthquake Information network – Worldwide info http://www.eqnet.org/. (Very informative.)
- NZ Society for Earthquake Engineering http://www.nzsee.org.nz/.
- Hazard Watch NZ http://www.hazardwatch.co.nz/. Hazard Watch provides weekly reviews of natural hazard events reported in New Zealand. Hazard Watch is a service of the Institute of Geological & Nuclear Sciences (GNS).
- Institute for Geological and Nuclear Sciences (New Zealand) – really good and informative site http://www.gns.cri.nz/

FAQs

- Moonquakes exist, but happen less frequently and with smaller magnitudes. They are thought to be related to the tidal stresses associated with the varying distance between the Earth and the Moon and occur at a great depth (around halfway between the surface and center of the moon).
- Largest recorded earthquake in the world was magnitude 9.5 (Mw) in Chile on May 22, 1960.

- The world's deadliest recorded earthquake occurred in 1556 in central China. It struck a region where most people lived in caves carved from soft rock. These dwellings collapsed during the earthquake, killing an estimated 830,000 people.
- It is estimated that there are 500,000 detectable earthquakes in the world each year. 100,000 of those can be felt, and 100 of them cause damage.
- The Institute of Geological & Nuclear Sciences locates about 10,000 to 15,000 earthquakes in New Zealand each year. Most are too small to be felt. Each year New Zealand has about 100 to 150 quakes that are big enough to be felt.
- The biggest known quake in New Zealand was the magnitude 8.2 Wairarapa earthquake of 1855. On an international scale, the 1855 earthquake is of major significance in terms of the area affected and the amount of fault movement. About 5000km^2 of land was shifted vertically during the quake. The maximum uplift was 6.4m near Turakirae Head, east of Wellington. The maximum horizontal movement along the fault was 12m.
- The biggest New Zealand earthquake since instrumental recording began was the 1931 magnitude 7.8 Hawke's Bay earthquake.
- Big earthquakes are not evenly spread. Between 1929 and 1934 New Zealand was hit by five major earthquakes of magnitude 7 or more. This is 10 times greater than the long-term average for earthquakes of magnitude 7. There is evidence to suggest that big earthquakes can accelerate or retard the arrival of another earthquake. It is thought they do this by shifting the balance of stresses in the Earth's crust.
- Seismologists have established a relationship between magnitude of the main event and the number and size of aftershocks. The relationship is indicative only. In general large, shallow earthquakes produce felt aftershocks. Deep earthquakes produce fewer aftershocks that are less likely to be felt. The rate of aftershocks initially decreases very rapidly with time, but for a large earthquake they can continue at a low level for years.
- Seismologists have investigated the effect of the moon's gravity for many years, and while the moon does deform the earth slightly in a 12-hour cycle called the solid earth tides, it doesn't seem to have an effect on the time an occurrence of big earthquakes.
- Geologists believe that if a fault shows evidence of having moved at least once in the past 100,000 years, it should be regarded as an active fault and a potential source of earthquakes. If it has moved at least once in the past 5000 years, then it should be considered a potential source of damaging earthquakes to any settlement within a radius of 50km.
- The direction of rupture influences the size of the impact in different places. This phenomenon has been observed many times in New Zealand and overseas. Seismic energy gets focused in the same direction as the direction of rupture – a kind of Doppler shift. So if you are unlucky enough to be in the line of fire, a magnitude 6.5 earthquake may hit you with the force of a much bigger quake. Other factors such as topography and rock type can also focus seismic energy in different ways. Many New Zealand faults trend northeast/southwest. This dictates the likely direction of rupture for these faults.
- For many years there have been suggestions that earthquakes occur more often during warm, still, humid weather. This observation is anecdotal and has no basis in science. International records show that earthquake occurrence is spread over all weather conditions, during all seasons of the year, and during both day and night.

SLOW EARTHQUAKES PUSHING NZ OUT OF SHAPE
(From the Institute of Geological and Nuclear Sciences Website)

Slow, silent earthquakes occurring deep under New Zealand are pushing parts of the lower North Island out of shape, scientists say.

Up to seven "slow earthquakes" have been recorded by scientists at Geological and Nuclear Sciences Ltd (GNS) since 2002. It is likely these events have always been occurring, but scientists have only been able to detect them recently with the advent of global positioning satellite equipment which can detect sub-centimetre land movements.

GNS geophysicist Laura Wallace says continuously operating GPS equipment is adding to the understanding of earthquake hazards in New Zealand.

The Pacific plate descends westward beneath the eastern North Island, but for most of the time the descending Pacific plate and the over-riding North Island are "stuck" together at their interface, which causes large parts of the eastern North Island to be pushed to the west.

Dr Wallace says that slow-slip quakes are a sign that this tectonic stress is being relieved by 'silent' land movements that are the result of slow slip occurring on parts of the plate interface at 15 - 30km depth beneath the North Island

They manifest themselves as large areas of land moving eastward by up to 30mm over days, weeks, or months. Some scientists believe that these movements can shift stress within the Earth's crust and trigger earthquakes. So they are not necessarily benign events.

GNS has detected these events at GPS sites at Gisborne, Hastings, Wanganui, Ashhurst, Dannevirke, and Paekakariki. Each event has a characteristic signal. Some happen within days and others are more leisurely, taking some months to settle.

Some of the events may occur quite regularly, with an event near Gisborne repeating after about 2 years. Some cause ground movement of just 5 mm, while others have caused 30mm of ground displacement.

One of the best-documented slow slip earthquakes in New Zealand has occurred from January to June of this year beneath the Manawatu region. This event caused 10 to 30 mm of eastward movement of GPS sites near Ashhurst, Wanganui, and Dannevirke.

The GPS site near Ashhurst has uplifted by up to 30mm over the last six months. GNS scientists suggest that this ground displacement has been caused by approximately 150mm of slip on the plate boundary beneath the Manawatu region. It is possible that this event triggered some of the many small to medium sized earthquakes in the lower North Island early in 2005.

Repeated GPS measurements have also enabled GNS scientists to deduce that the area where the plate interface is most 'stuck' is beneath the southern North Island , but that there are also small areas where the plate interface is stuck beneath the northeastern North Island.

As more continuous GPS instruments are installed as part of the GeoNet project, it will enable scientists to track these events with more precision. This will lead to greater understanding of the seismic hazard posed by the plate interface beneath the North Island.

Canterbury Disaster Salvage Team
Earthquake Mitigation and Response – Practical Exercise
April 2006
(2 days)

Draft Programme

Day 1

1. Introduction
2. Housekeeping
3. Introductory level talks about
    a. Earthquakes
    b. Earthquake risk specific to Canterbury and South Island
    c. Other associated events: tsunamis, landslides, etc
4. Demonstration of Shake table
5. Discussion - post-earthquake issues
6. Earthquake "Recovery" of items on shake table

Day 2

1. Recovery of Earthquake material, con't
2. Discussion about recovery of wet material
3. Recovery of 'Earthquake' material in wet stations
4. Debrief and question period – sharing lessons from the past two days.