
SEISMIC SCIENCE
THE NEW ZEALAND TEXTBOOK EARTHQUAKE
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SEISMIC SCIENCE – the New Zealand textbook earthquake
2 HOUR SPECIAL

Introduction

On 4th September 2010 at 4.35 in the morning Canterbury, New Zealand experienced a massive, yet 'perfect' earthquake.

At magnitude 7.1, this quake released the energy equivalent of 1000 Hiroshima atomic bombs and slammed the city of Christchurch, just 40kms from the epicenter. People were thrown from their beds and feared for their lives as the ground roared. Solid land turned to liquid, homes fell apart and chimneys crashed through roofs.

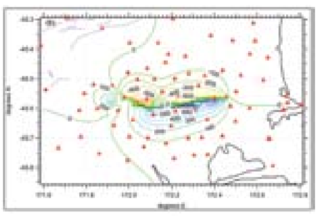
Unbelievably though, when the shaking stopped, no one had died and only two people were seriously injured. Just eight months earlier a similar size earthquake (7.0) hit Haiti and 230,000 died. In 2003 a 6.5 in Iran killed more than 26,000 people.

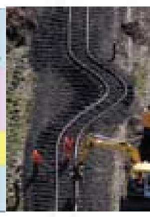
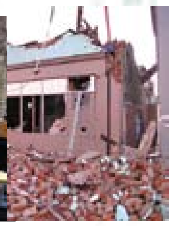
How can a city not known to be sitting on a fault line, come through such a large natural disaster without a death toll? This unknown fault erupted abnormally close to the surface, large cracks in the land, buckling roads, broken fences, and rivers changing course have left an inconceivable scar across the countryside.

Within days international scientists arrived from around the world to view, measure and monitor this extraordinary fault line and quake.

With modern technologies such as seismometers, GPS, laser scanning, and satellites, this earthquake and its aftershocks quickly became the best recorded in the world.

Many countries around the world sit on fault lines, both known and unknown ones. For those in the firing line, the story of the Canterbury quake provides invaluable scientific data on how earthquakes occur, and most importantly, how a major disaster can be survived.

Content & Structure

CONTENT OVERVIEW

Seismic Science reveals the science behind this textbook quake. Told chronologically we draw from all areas of science to look at how and why the quake occurred, the impact on the land and the people, and to discover what made this earthquake so exceptional.

We speak with earthquake scientists from all over the world about faults, ruptures, energy dissipation and the more than 4,200 aftershocks the region has suffered. We learn from geologists about soils types, and liquefaction - where the shaking ground turns to jelly under you.

We talk to engineers about the designs of buildings, roads, and bridges, and see why some survived and others didn't. We learn about water tables, broken pipes, and the disruption of drinking water supplies and sewer systems.

We hear from disaster recovery experts who consider the immediate disaster response text book in its efficiency and coordination. And social scientists are looking at the impact on the people – what survival skills they used, and the impact on the elderly and the young.

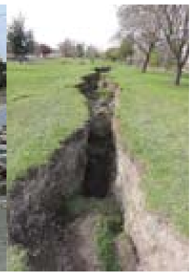
SEISMIC SCIENCE- The New Zealand Textbook Earthquake

Living on the Ring of Fire

As the Australian plate slides horizontally towards the northeast, the Pacific plate is pushing up, creating the large Alpine Fault, which runs the length of the South Island. When Canterbury shook on September 4th, many people thought the overdue Alpine Fault had ruptured, but scientists excitedly discovered it was a previously undetected fault, hidden beneath Canterbury's flat alluvial plain that was on the move.

New Zealand experiences about 14,000 earthquakes a year and looking back we see a worrying history of death and destruction.

Looking at Canterbury and Christchurch in 2010 though, we see a picturesque English-style city of 400,000 people, known for its beautiful gardens and conservative culture. A sedate and orderly city surrounded by very well manicured farmland.



Earthquake
The Ground Shakes

At 4:35am on September 4th the rupture of a fault just 10km beneath the Canterbury Plains produced a magnitude 7.1 earthquake that released massive seismic waves throughout the region.

CCTV footage, personal stories, interviews with scientists, animations and TV archive footage create a dramatic retelling of the moments the earthquake struck.

People describe the noise as like a truck or plane crashing in their home. They recall buildings breaking around them, mud and water oozing up into their homes, and remember stumbling around in the dark to look for family members and torches.

Scientists monitoring the web of seismometers in the region determine the size and epicenter of the quake within minutes.

The national disaster response service is up and running within ten minutes.

The day dawns on scenes of destruction; piles of rubble, fallen chimneys, broken houses, streets cracked wide open, flooded homes and ruptured land.

As the hours pass scientific data starts to trickle in, building a more detailed picture of the quake. The newly discovered and named Greendale Fault is a strike/slip fault (with a right-lateral focal plane striking east-west) that has been buried for more than 16,000 years.

Using computer animations seismologists build a full picture of the quake explaining the epicenter, moment magnitude, ground acceleration, depth, fault length, seismic wave frequency, and felt intensity.

"We are all seismometers really",one says, as people describe how they experienced ‘felt intensity’.

The timing of the quake has saved many lives. Emergency response teams express surprise that the expected influx of deaths and injuries isn’t happening

Power and water supplies have come to a halt for large swathes of the city. A state of emergency is declared at 10:16 am. The city's central business district is shut down and the New Zealand Army is deployed to assist Police.

As the emergency assessment swings into action, more scientists speed into the field to begin a rapid collection of precious perishable data. Amongst them an American scientist who had landed in Christchurch only 12 hours earlier.

"Within three hours of the earthquake, a reconnaissance and response team led by scientists had been deployed. At the epicentral area, the reconnaissance team located the first evidence for ground-surface fault rupture at 9:30 am and began to assess hazards to the affected community and conduct detailed measurement of fault offsets across roads and fences."

A helicopter reconnaissance flight captures outstanding aerial photographs of the fault line and by the end of the day; a first approximation of the rupture length and general damage patterns is established.

The data is captured using a range of leading technologies; a wide network of seismographs, satellite radar images, aerial photographs, GPS measurements and aerial laser scanning.

"This is arguably the best recorded and documented earthquake in human history. From the amazing datasets we have collected we will be able to understand how major strike-slip faults rupture (with relevance for understanding other strike-slip faults, such as those in California), and how faults grow."

Lifelines

The 'Lifelines' of a city are its power, water, phone, and transport. New Zealand is a world leader in earthquake engineering and we start to get a picture of how this city has spent years preparing its lifelines for this big shake.

A manager at a local power station explains that while most of the city lost power, this was a planned response. Roads have cracked wide open and rails lines have twisted out of shape.

An engineer visits some still-standing bridges, supermarkets, city offices, and schools illustrating how seismic design and engineering has paid off. Water and sewer pipes have not fared so well. Traveling around the city you see broken pipes gushing water, and manholes and pumps that have popped out of the ground.

Most water mains are asbestos-cement pipelines and wastewater pipelines are mostly reinforced concrete conduits. These pipes broke and separated, and over 11,000 tons of liquefied sand and water entered them. Sewer and waste is pumped directly into local rivers making them a no go zone for months.

More than 25km of water pipes and 70km of wastewater pipes will need replacing. Some areas have no water or sewer for weeks as a result of the devastating impacts of liquefaction.

Liquefaction

Liquefaction is one of the most dramatic science stories of this quake, and is of huge interest to other countries in quake zones. (Liquefaction was also a major cause of destruction in the 1964 Niigata earthquake and in San Francisco's 1989 Loma Prieta earthquake.)

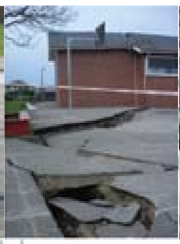
Liquefaction occurs when severe shaking turns previously solid earth into a liquid. In Christchurch it caused as much, if not more damage than the shaking. Within seconds the sloppy mass formed 1-5 meters below the surface, and as the pressure built, sand, mud and water spewed to the surface. Buildings broke in half or slid sideways, floors cracked, pipes broke, and roads shifted as the ground under them liquefied and spread.

Computer animations model liquefaction and demonstrate how the resulting lateral spreading and differential settlement of the land causes so much damage.

The story of the 'student army' provides a warm human face to this story. With the University closed, one student used Facebook and Twitter to recruit a 1600 strong 'army' of young volunteers. They turn up day after day in the worst hit suburbs, shoveling the liquefied sand and mud off streets and out of the back yards of shocked and grateful homeowners.

Meanwhile geologist and engineers enthusiastically measure and map the effects of liquefaction.

"The liquefaction damage is one of the truly remarkable features of this earthquake. The challenges of rebuilding on liquefaction-prone land are of great interest to the international community."


Scientists Unite

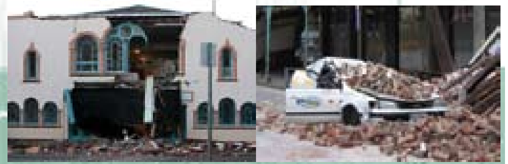
The communication, coordination and rapid sharing of information between different branches of science greatly contribute to the exceptional data set that is collected.

Images from the air show how the 29km of the fault line is mapped by tracking damage to train tracks, fence lines, lines of trees, roads, and rivers.

The dramatic story of the Hororata River shows a river sitting right across the fault line, cut in two. With more complete data, scientists now realize the quake is an extremely complicated event, with the shear stress released 10 to 20 times more than expected.

"For its magnitude, this earthquake was unusually efficient at generating seismic waves."

The epicenter is located not on, but just to the north of the large Greendale Fault and they discover the quake was caused by not one, but four fault lines, all rupturing within seconds of each other.



Aftershocks

"The quake was bad but it is the aftershocks that are really stressing people out."

Within the first 48 hours, 63 aftershocks hit the region, with three registering magnitude 5.2. In the coming four months more than 4,200 of these hammer the city, causing further damage to buildings and straining nerves to breaking.

'Guess the magnitude' becomes a popular game with Cantabrians, and traffic soars at the GeoNet website, which reports the magnitude of each aftershock, as the 'human seismometers' checked their estimates.

Within days the Stanford University 'Quake-Catcher Network' program arrives in town. Over 180 volunteers offer their homes and computers for installation of miniature seismometers so the impact of aftershocks can be recorded.

"Ground motion can quite strongly depend on the local geology or the local site. Local variations in ground motion occur during aftershocks".

The Aftermath - Recovery and Rebuilding

Early European settlers quickly learned the importance of using appropriate building methods in this earthquake-prone country. It is years of earthquakes and experience that have created the strict building codes New Zealand has today. Many Cantabrians owe their lives to the engineers and building assessors who insist on buildings that do not collapse when shaken.

The masonry falling on sidewalks, on outdoor restaurants, and on neighboring smaller buildings would have caused many casualties if the earthquake had struck at a different time. These types of buildings pose an extremely high life safety risk and are very similar to buildings found in the USA and Canada.

Two historical brick masonry buildings side by side tell the story - the strengthened building is undamaged; the other has walls collapsing off the front of it. Earthquake engineers explain how building designs have improved and Christchurch Women's Hospital is a great example. Just five years old it is the only seismically isolated building in town and this modern design technology has done it's job.

Most local housing is single story and has fared well. The liquefaction suburbs have not come off so lightly with approximately 3,000 dwellings likely to be demolished or need large scale repair work.

Chimneys particularly showed vulnerability with over 14,000 of them damaged or collapsing completely. Homeowners have been recommended to dismantle chimneys for their future safety.

"We need to think about what happens to our houses and building. Do we tear them down, do we need to change the ground underneath and how much ground do we need to change. How long is the ground going to be sinking and how long are these cracks going to appear in the land? This is the interface between geology and engineering."

After Shocks Continue

In the months following the quake, initial scientific papers, lectures and results start to emerge, but the science is ongoing as the land is still moving.

Water tables are still changing, river systems have moved, and the ground is still settling. Buildings are being demolished, roads repaired and many people are still out of their damaged homes. We start to see some of the longer-term impacts; one official says those in the affected areas can expect 'up to two years of chaos' and living in limbo.

Scientists give us an update on their discoveries. What are they learning that could save lives in other earthquake zones. Can they tell when other hidden faults may move? What have they learnt about the way faults rupture? And what new information is there about liquefaction and how this can be mitigated? Repairing the land damaged by liquefaction is a massive task.

For some areas engineers are developing a plan to install huge underground dams of stone going down to 100meters to protect riverbanks and properties in vulnerable liquefaction areas.

Christchurch is still in the firing line for another big quake from the Alpine Fault and Dr Rupert Sutherland is leading a team of researchers in one of the biggest experiments on a fault line ever conducted. This multimillion-dollar Deep Fault Drilling Project hopes to drill two boreholes about 150 meters deep and about 50m apart in an area where the fault runs unusually close to the surface. Researchers will analyze rocks from the boreholes and also lower devices into the holes to determine how rocks have been broken and altered. Scientists from Britain, Germany, Canada, the United States and Japan will also take part in the project.

The Human Factor

Social scientists have also been busy since the earthquake and much of their research is still in the data-gathering phase -

- how well people took cover during the quake
- the psychological affects of the stress of the earthquake and aftershocks
- how well social welfare services responded,
- waste management of the debris that was created
- how the elderly coped

The earthquake and subsequent aftershocks are likely to rank globally as the fifth most costly quake ever for insurers. With over 160,000 claims at a cost of NZ$3-$4billion this is by far the biggest insurance event in New Zealand's history.

Many people commented on how well Cantabrians coped with the disaster, staying calm, helping neighbors and working together to clean up and rebuild the city.

Fortunately the government-run Earthquake Commission has been charging homeowners levies since 1945, building up a nest egg of insurance funds for just such an event as this.

The Textbook Quake

In the final segments of this documentary we review the factors that made this the 'perfect' earthquake. For scientists the quake was shallow and visible in a well-monitored area. It was close to a University so measuring and recording data before it disappeared was fast and easy.

For those who survived it, it was 'perfect' for other reasons. No one died. The timing was good, there was a first-rate emergency response, community spirit was strong, and most buildings stayed standing.

The information gathered will take years to fully analyze but already it is providing scientists around the world with remarkable new insights into how and why earthquakes occur, what happens to the land during and after a quake, and what cities living on fault lines can do to better prepare and protect their citizens.

Treatment

This blue-chip documentary brings together cutting edge CGI technology from Animation Research Ltd along with CCTV footage, personal stories, expert interviews and TV archive footage to engage the audience as we reveal and explain the science around the Canterbury earthquake.

Shot on HD, using natural light to capture the heart of the earthquake scenes, with well-lit expert interviews giving us the scientific facts. Well-crafted sequences with good quality sound are a priority, with sound-scape adding another powerful layer to the documentary.

Timeline

Production
Immediate start, with shooting continuing until final on-line and audio post deadlines and signoff

28th July 2011
Delivery

4th September 2011
On air - anniversary date

Key Personnel

Production Company

Paua Productions Ltd
Christchurch Music Centre
PO Box 1051, Christchurch, New Zealand

Paua Productions has decades of experience working with New Zealand and international networks including BBC, Natural History, National Geographic, Discovery Channel, Al Jazeera, TVNZ, TV3 & Prime/Sky providing innovative prime-time television programmes.

Independent producers Veronica McCarthy and Virginia Wright each bring more than 20 years experience and hundreds of screen credits to the table, delivering award winning documentaries, factual, children's and reality television programmes.

Giving viewers insights into real people in the real world is our current focus, yet the strength and breadth of our past work extends from docu-dramas to children's series, and allows for screen production in many genres.

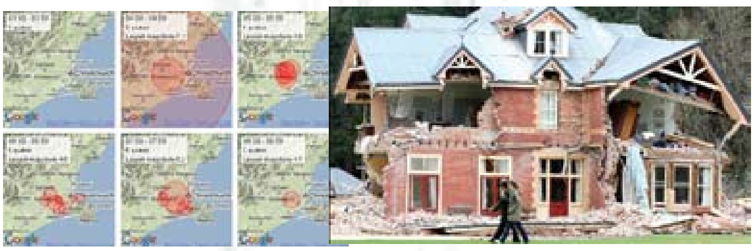
Integrity is our core value and we produce compelling entertainment with high production values on time and on budget.

Producer
Veronica McCarthy

Director
TBC

CGI Animation

Animation Research Ltd



Potential Participants

New Zealand is a world leader in this field; equally there are a number of international earthquake experts we can draw on.

International Experts

- Dr Kevin Furlong, Department of Geosciences, Pennsylvania State Univer sity
- Prof Mary Comerio, Disaster Recovery, University of California, Berkeley

New Zealand Experts

- Dr Thomas Wilson, Geologist, University of Canterbury
- Dr Mark Quigley, Seismologist, University of Canterbury
- Dr Erica Seville, Risk Management, University of Canterbury
- Prof Greg McCrae, Structural Engineer, University of Canterbury
- Kirsti Murahidy, Geotechnical Engineer, Tonkin and Taylor, Christchurch
- Dr Rupert Sutherland, Tectonic Geologist, GNS Science
- Prof Stefano Pampanin, Structural Mechanics and Design, University of Canterbury
- Dr Kelvin Berryman, Manager of Natural Hazards Platform, GNS Science
- Prof Misko Cubrinowski, Geotechnical Engineering, University of Canter bury
- Gerry Brownlee, Earthquake Recovery Minister, Central Government
- Residents of Christchurch