NCEA and the Rū Seismology Programme

Glenn Vallender

info@edrsr.co.nz and www.edrsr.co.nz

CONTENTS

Ed R SR

Educational Research &
Science Resources Ltd

VERY BRIEFLY

- There was early dissatisfaction with the ‘scalable’ norm referenced school certificate, UE and bursary ‘examination’ systems.

- PPTA led the movement away from norm referencing to criterion referencing and then to standards based assessment particularly from the 1960s on.

- Norm referenced exams were designed as a filter for the ‘professions’ v’s ‘trades’ and this conflicted with ‘neo liberalism’ or ‘Rogernomics’ of mid 1980s.
  http://www.victoria.ac.nz/education/research/nzaroe/issues-index/1992/abstract-dale

- NZQA was introduced as a separate but connected entity in 1990 and trials of SBA began as ABA (Achievement based assessment) for 6th form certificate. This then moved to Criterion Referenced unit standards but was never fully supported by teachers and led to work bans in the 1990s.

- The qualifications framework Inquiry (QFI) of 1995 and endorsed by PPTA in 1997 led to development of the NCEA.

- NCEA continues a fragile existence from its ‘early’ inception ‘ in 2002 when it replaced School Certificate.

http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/history-of-ncea/where-did-ncea-come-from/

Selected Milestones in NZ Education

2007 National curriculum
1994 National curriculum
1988 Tomorrow's schools
1968 National curriculum

- **The Thomas Report** of **1944** gave us *'education for all'* and UE (School Cert came in 1934).
- The **Atmore Report** of **1930** made school compulsory from age 7 to 15 and put less emphasis on 'academia'.
- **Education Act of 1914** gave 'free' education to all who passed the norm referenced 'proficiency exam'. Designed for social hierarchies?
- Introduction of 'Technical schools' around **1900** for economic growth, but they struggled to become established and eventually disappeared.
- **Education Act of 1877** established 'free', compulsory and secular education that was aimed at increasing secularism and establishing consistent standards.
- Colonial education **dominated** by **church and private schools**
- First NZ school in **1816** run by the *Anglican Church Missionary Society* with Thomas Kendall. A fascinating story of cultural ignorance and arrogance.

http://www.elsewhere.co.nz/writingelsewhere/2739/

Pre European education was shared between home and community with specialists teaching 'law and traditions' to sons of chiefs in whare–wananga

(See http://www.trc.org.nz/Maori_education)

GSNZ and Geoscience Education

- Only snippets of Geol/geoscience education issues are raised in the GSNZ newsletters from 1954 to 1981 but its importance was recognised very early on and probably pre GSNZ as well.
- **1983** (issue 59, p26) formally sees the **formation of the Geological Science Education SIG** in Dunedin with Jack Grant-Mackie, Richard Norris, Daphne Lee and Glenn Vallender.
- Early discussions of Geol/geoscience Ed in schools in **1984** with D. Lee's survey of schools providing valuable demographic information.

- **1986-92** discussions on the place of Geoscience in the Science curriculum reforms in development of Unit standards.
- GSNZ has a strong history of supporting the development of Earth and Space Science (ESS) at NCEA Levels 2 and 3 and for scholarship.
- Development sees earth system science as an underlying principle for geoscience in the curriculum (e.g. inclusion of as91413).
- Geoscience student numbers decline at secondary school.

Enter the 'New' Geoscience Curriculum

1968 curriculum → **N**o geological science. Syllabus dominated by geography.

1993 curriculum → Introduction of *Planet Earth and Beyond* with rocks and minerals externally assessed at Level 1 Science.

2002 → **F**irst external NCEA exam in *"Aspects of geology"* included rocks, minerals and geological history.

2005 → '**M**inerals' is **removed** from the geology standard at Y11.

2007 current curriculum → **R**evised national curriculum developed. Nature of Science and key competencies become emphasised.

2011 → External geology examination at level 1 **abolished** and Geoscience becomes internally assessed. *"Aspects of geology"* standard is **removed** and replaced with *"NZ surface features" and the "Carbon cycle".* C cycling is an attempt to integrate 'Earth System' thinking into science.

2012 → **E**arth and **S**pace **S**cience becomes a scholarship subject

2014 → Ru seismology for schools programme established

http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/history-of-ncea/where-did-ncea-come-from/

Development of the Rū Seismometers for schools programme

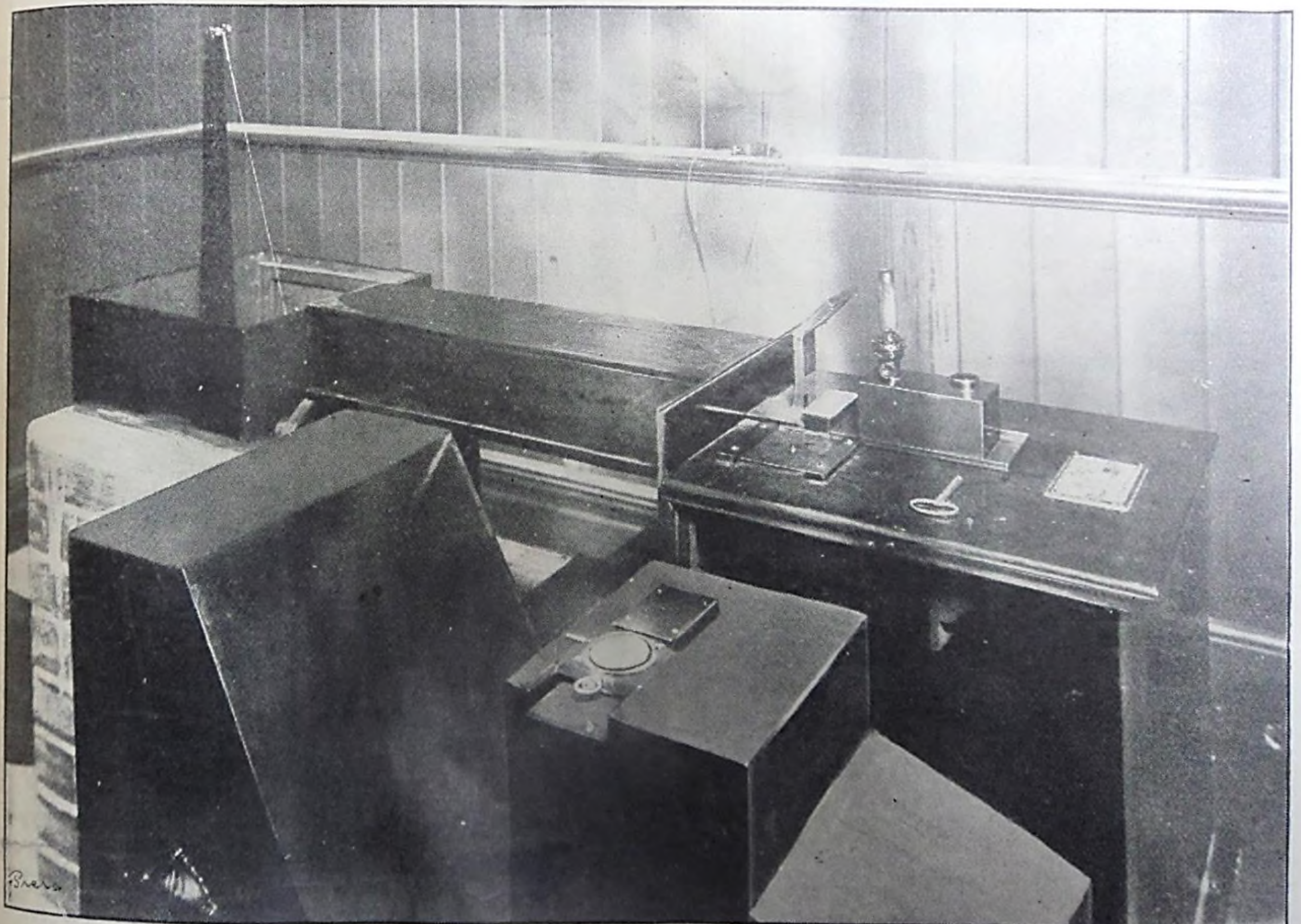
Predecessor

- **Quake Trackers** was first developed at VUW by John Taber and Warwick Smith in collaboration with GNS (IGNS then) in 1998. Geophones were used. Hamish Campbell was director in 2002.
- Quake Trackers faded out by early 2004 with up to 15 schools having been involved.
- The geophones were to be replaced using AS-1 horizontal seismographs but this did not ‘get off the ground’ due to staff changes, high costs, institutional structure changes, rapid software development and curriculum changes such as introduction of NCEA unit standards then achievement standards!
- The original website no longer exists.

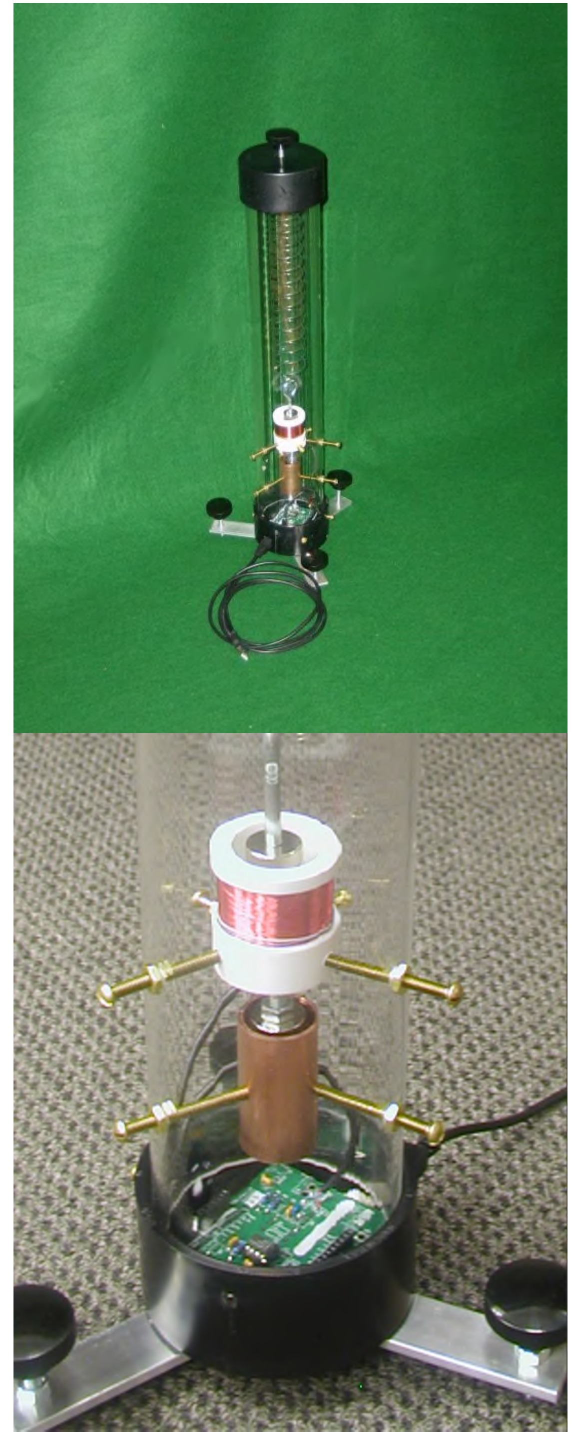
Today

- Kasper Van Wijk, Ted Channel and others at Boise State University develop the TC-1 vertical seismometer. Kasper transfers to Auckland University and gains funding from SEG and EQC to establish the first seismometers in NZ schools in 2012.
- In 2015 there were 6 TC-1s in the South Island and 12 in the North Island.

THE OLD (Milne, 1901)



MILNE HORIZONTAL SEISMOGRAPH, FOR THE PURPOSE OF RECORDING EARTH TREMORS.
The record is taken by means of photography, the light for which passes through a hole in the end of a boom, any movement in which is shown upon the sensitised paper in the instrument. The watch seen near the front of the picture records the time at which the tremors occur.



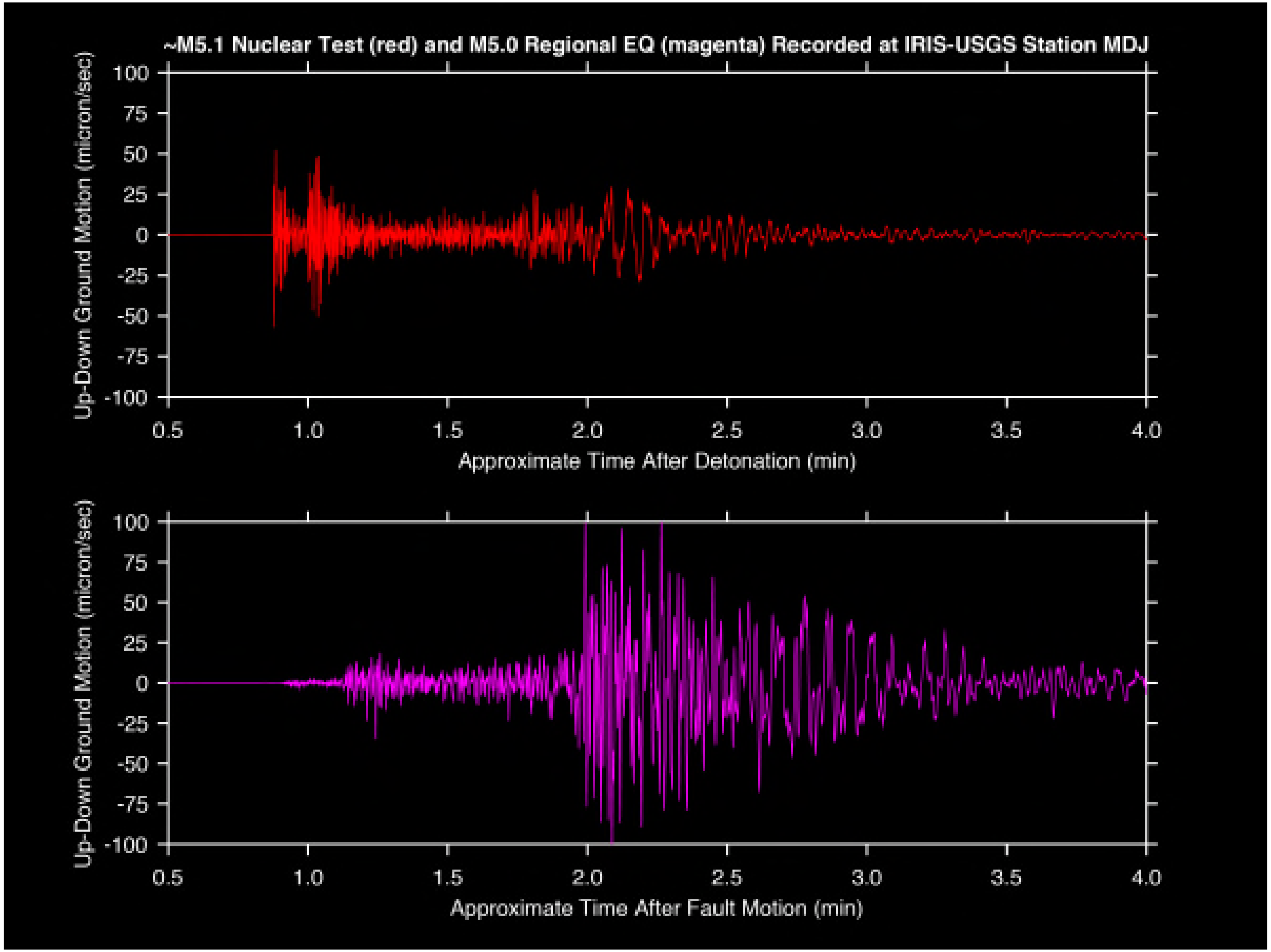
THE NEW (TC-1, 2016)

USING the Ru Programme for Teaching and Learning

- **Teachable moments** (e.g. responses to seismic events)
- **Assessment tasks** (e.g. physics as91169)
- **Monitoring /observation science** (e.g. data collection and processing)
- **Data processing** (e.g. graphing and mapping)
- **Communicating Science** (e.g. phones, tablets, IT)
- **Content teaching** (e.g. earthquake measurement and distribution, earth's interior,)
- **Conceptual teaching** (e.g. seismic wave properties and propagation, energy and wave theory)
- **Socio scientific issues** (e.g. issues raised from the Canterbury earthquakes and preparation for a M8 on the Alpine/ Wellington/ Awatere faults).

Teachable Moment example The North Korean M5.1 nuclear test

http://ds.iris.edu/ds/nodes/dmc/specialevents/2016/01/05/2016-north-korean-nuclear-test/



Comparison: 2016 North Korean nuclear test and 2005 M5.0 earthquake, both at similar distances from seismometer. (Andy Frassetto, IRIS)

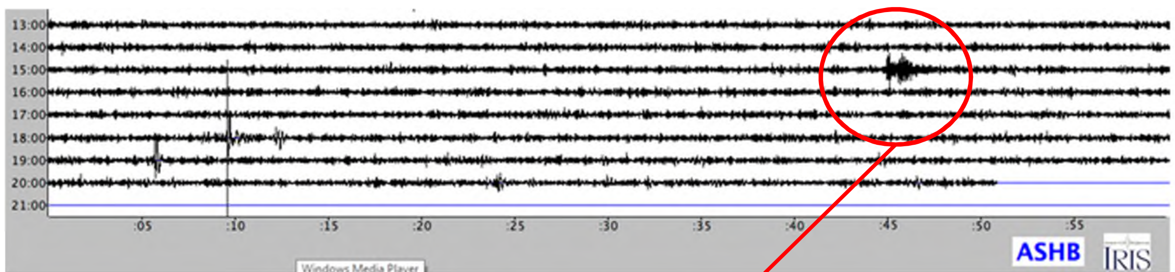
Communicating Science

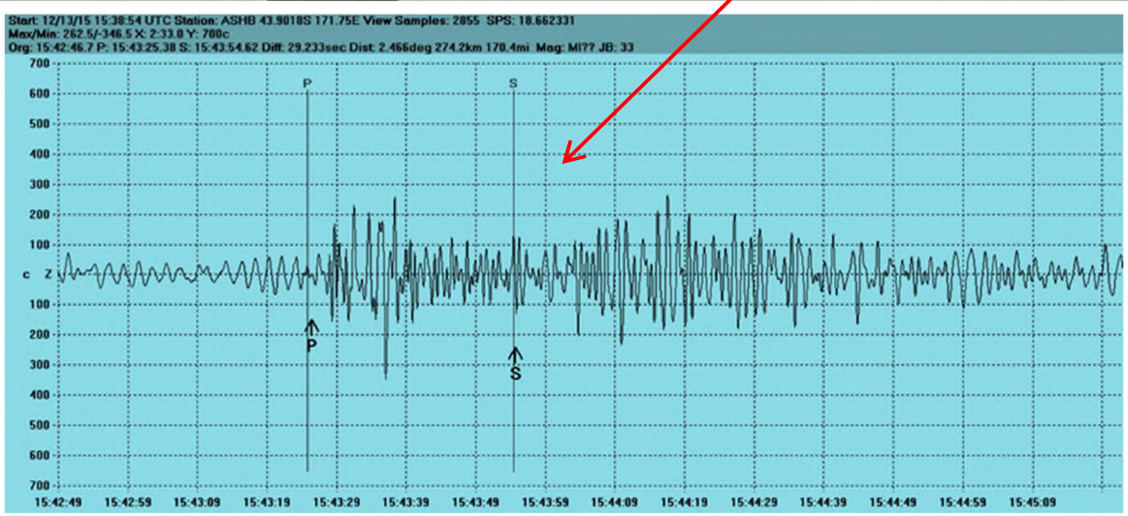
LATEST EARTHQUAKE
RECORDED AT THE ASHBURTON MUSEUM

Sunday December 13, 2015. 15.42.41 GMT

Magnitude	= 4.46
Depth	= 6.25 km
Location	= 54 km NE Inangahua
Dist. from Ashburton	= 274 km

https://www.freemaptools.com/measure-distance.htm

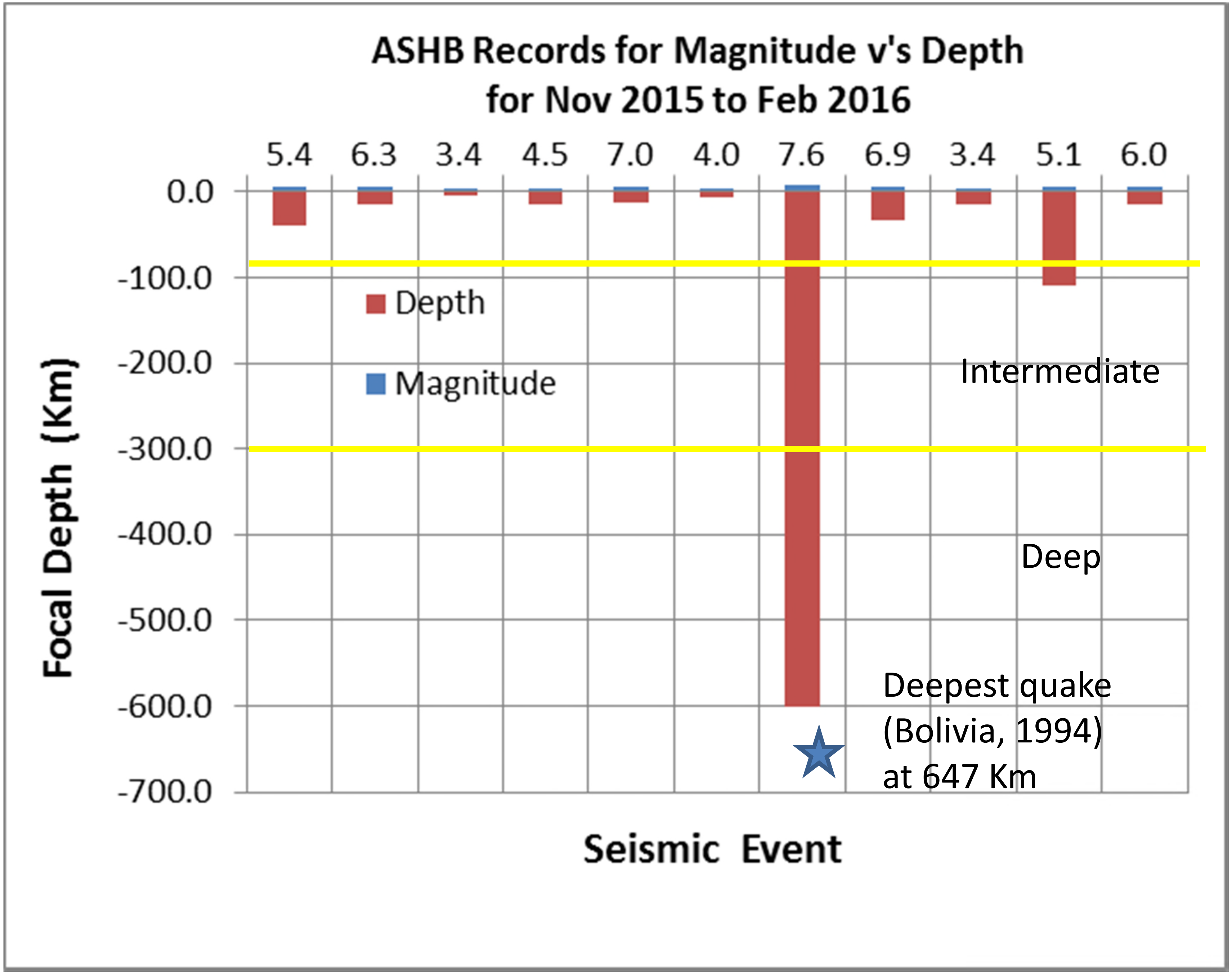




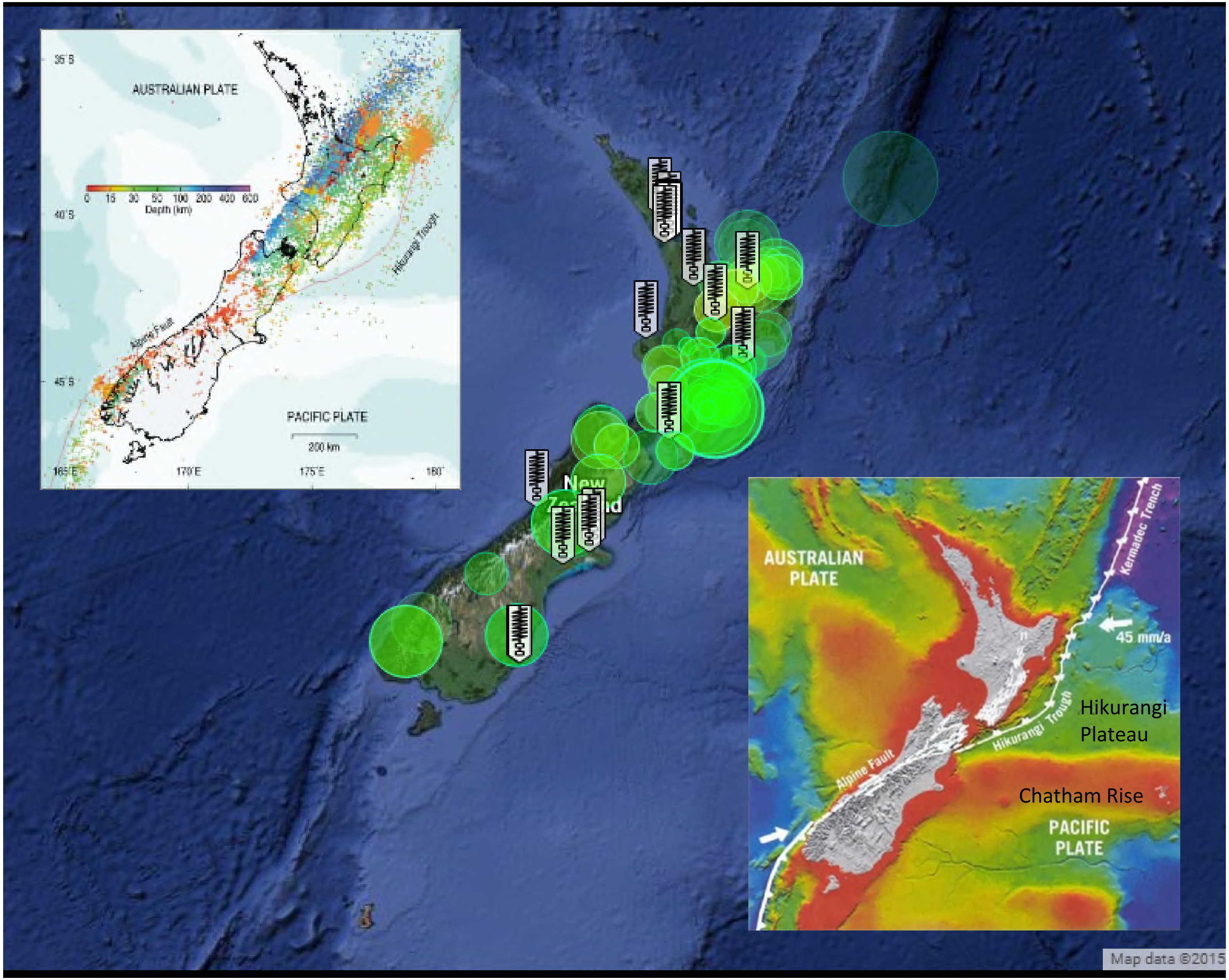
Summary Table of Earthquakes recorded at ASHB for the Rū network programme

ID #	Date D/M/Y	Origin Time GMT	Magnitude Mw	Focal Depth (Km)	Epicentre Distance from ASHB (Km)
048	01/11/2015	05.42.11	5.4	39	615 (Waiouru)
049	04/11/2015	03.42.15	6.3	14	5,969 (Timor)
050	10/11/2015	12.11.02	3.4	4	61 (Rolleston)
051	11/11/2015	20.03.07	4.5	15	178 (Lake Hawea)
052	19/11/2015	18.31.04	7	13	4,149 (Solomon Is)
053	20/11/2015	14.02.36	4	7	310 (Seddon)
054	24/11/2015	11.45.38	7.6	600	10,752 (Peru)
055	09/12/2015	10.21.50	6.9	34	6,057 (Indonesia)
056	13/12/2015	02.23.00	3.4	14	43 (Mt Alford)
057	31/12/2015	19.50.50	5.1	110	360 (Cook Strait)
058	18/01/2016	18.24.19	6.0	15	2,176 (Fiji Trench)

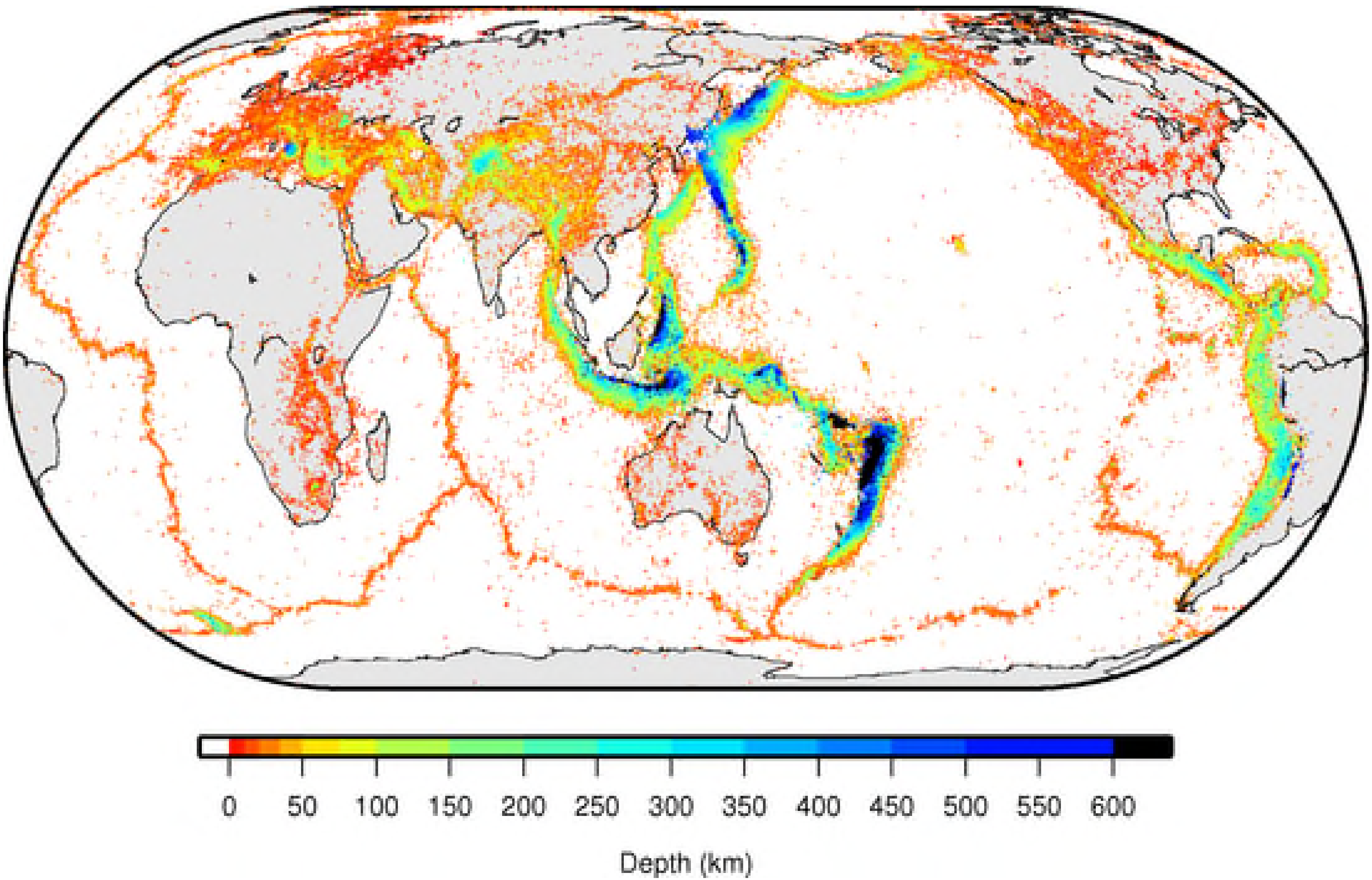
Data Processing



The Ru screen December 30th, 2015 3.27 pm



Seismicity and plate boundaries



Discussion questions to ponder

- Is there a place for teaching aspects of seismology in your teaching programmes? Where?
- What are the barriers to implementing a teaching programme on seismology?
- Who decides what is taught at your school?
- Why do you teach what you teach?
- Are you controlled by NCEA credit accrual or by learning?

THANK YOU FOR YOUR ATTENTION

Hmmmm

$$Magnitude = \frac{\log_{10}(Energy) - 11.8}{1.5}$$

This is why physics AND science teachers should not do grounds ‘duty’

“The most important single factor influencing learning is what the learner already knows”

Ausubel, D.P. (1968). Educational Psychology: A cognitive view. New York. Holt, Rhinehart, and Winston, Inc. 685p. (Ausubel 1918 – 2008).

How can seismology be integrated with NCEA Assessment standards?

Note: assessment standards are **derived** from the national curriculum and are not the national curriculum itself.

In practice however......

http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/the-facts/factsheet-2/

Relevant Level 1 Science (all internal 4 credits)

90942 Investigate implications of wave behaviour for everyday life (e.g. origin and propagation of seismic waves and implication via magnitude energy release for people and landscapes).

90952 Demonstrate understanding of the formation of surface features in New Zealand
(e.g. crustal deformation, folding, faulting, role of seismology)

90955 Investigate an astronomical or Earth science event
(e.g. the Nepal quake of 2015 as an earth science event or the Darfield quake of 2010)

Seismology and Level 1 Science Assessment Standards

as90942 (Waves) and **as90955 (Context to Canterbury earthquakes)** (8 credits here)

Key point is to carefully read the title and criteria of the standards and the conditions of assessment although this can sometimes appear to contradict the standard

Science 1.3. Internal. 4 Credits. as90942
Investigate implications of wave behaviour for everyday life.

Investigate information. The aim here is to locate and select primary and/or secondary information for the report by using an investigation or research approach.
Report on the implications of waves in everyday situations
An **implication** involves an application of the science that links to a use by society. For example: the science that lies behind earthquake waves and the damage they cause. Reporting on implications of waves on everyday life is the critical component of this standard.

http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/subjects/science/science-clarifications/level-4/as90942/

as90955: Investigate an astronomical or Earth Science event (4 credits internal)

The outcome of this standard has two key parts:

1. **Investigate information.** The aim here is to locate and select primary and/or secondary information for the report by using an investigation or research approach.
2. **Report** on an astronomical or **Earth science event.**

The event here could be the Canterbury earthquakes and is the context for as90942 on seismic waves.

Data can be collected individually or as part of a group.
Students must provide evidence that is at the national standard for **both** key parts.
Authenticity is the schools responsibility.

A range of research evidence, experiments, videos, etc, may be supplied by the teacher. This evidence can include primary and/or secondary information.

Physics Assessment Standards for using the Rū TC1 seismometer and data

NCEA LEVEL 1 (Curriculum level 6)

90936 Demonstrate understanding of the physics of an application
2 CreditsInternal

NCEA LEVEL 2 (Curriculum level 7)

91169 Demonstrate understanding of physics relevant to a selected context
3 CreditsInternal

NCEA LEVEL 3 (Curriculum level 8)

91522 Demonstrate understanding of the application of physics to a selected context 3 CreditsInternal

91527 Use physics knowledge to develop an informed response to a socio-scientific issue 3 CreditsInternal

Level 2 Earth and Space Science (ESS)

91187 Carry out a practical Earth and Space Science investigation
(e.g. Using the TC1 SEISMOGRAPH)

91188 Examine an Earth and Space Science issue and the validity of the information communicated to the public
(e.g. Rū, GEONET, IRIS, USGS)

91189 Investigate geological processes in a New Zealand locality
(DISTRIBUTION and MAGNITUDE OF EARTHQUAKES,
EARTH’S INTERIOR)

Level 3 Earth and Space Science (ESS)

91410 Carry out an independent practical Earth and Space Science investigation
(e.g. Using the Ru data, amplitude and distance?)

91411 Investigate a socio-scientific issue in an Earth and Space Science context (e.g. Planning for large earthquake events)

91412 Investigate the evidence related to dating geological event(s)
Seismology?

91413 Demonstrate understanding of processes in the ocean system
4 Credits External

91414 Demonstrate understanding of processes in the atmosphere system 4 Credits External

An Assessment Task Example

Teacher Guide

PHYSICS 2.2 Internal Assessment Task AS 91169. Vers.1

Title: “Demonstrate understanding of physics relevant to a selected context”

Level: 2 3 Credits

Note: This standard requires students to **demonstrate understanding** by giving appropriate explanations. Quality, validity and justification of scientific explanations provide evidence for achievement with merit or excellence. The selected context can be teacher or student derived but must be relevant to Curriculum Level 7 of the national science curriculum and relevant to modern physics. The context must cover a range of physics concepts. This task considers the clarifications provided by the national moderator in May, 2015. Paraphrasing of information does allow student demonstration of understanding of the physics involved. Authenticity of student work is verified by the provider/teacher (NZQA clarifications).

RESOURCE TITLE: The Physics of a Seismometer

Context/setting

This assessment task is a directed research assignment and involves student preparation of and presentation of a structured research report which describes the physics involved in modern seismometers.

Conditions

Students do their own research and write up their reports individually.

Timing: One week of in and out of class time with 2 hours in class time for writing up.

Format: **A written report** that includes relevant diagrams and graphs.

Information sources: All sources not generated by the student are to be appropriately acknowledged and recorded in a traceable format.

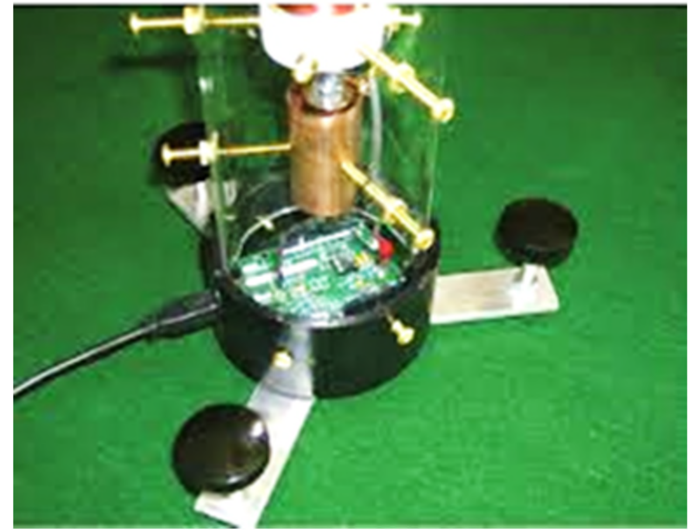
Achievement Criteria physics 91169

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate **understanding** of physics relevant to a selected context.	Demonstrate **in-depth understanding** of physics relevant to a selected context.	Demonstrate **comprehensive understanding** of physics relevant to a selected context.

Useful web based sources:

https://nzseis.phy.auckland.ac.nz
https://tc1seismometer.wordpress.com/
https://www.iris.edu/hq/sis/resources/seismometers
http://cgiss.boisestate.edu/bsu-network/history-of-the-tc1-seismometer/
http://demonstrations.wolfram.com/VerticalPendulumSeismometer/
http://cgiss.boisestate.edu/bsu-network/seismology/waves/
http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Earthquakes

STUDENT INSTRUCTIONS



Photo's courtesy of the 'Seismometers in schools Programme' (Auckland University),

Introduction

Earthquakes are a geological phenomena that have caused havoc for people for thousands of years. The Great Lisbon earthquake of 1755 triggered their study in a scientific way. The first seismometers measured a likely direction of an earthquake but were nothing like todays electronic instruments. Timing mechanisms did not appear until the 1880s.

In this assessment task you will research the physics involved in the working of a modern seismometer.

Assessment Conditions:

Format: A typed or hand written report with relevant illustrations and graphs.

Timing: 1 week in and out of class time with two periods (2h) to write up.

Amount: Between 4 and 10, A4 pages.

Due Date:

Student Instructions

You will work on your own to research and prepare a scientific report on the physics involved in the TC-1 seismometer. You should include descriptions and scientific explanations for how components of the seismometer work. This may include electromagnetic induction, data logging, harmonic motion, inertia, seismic wave forms etc.

All information sources used must be listed and in a traceable form. You are encouraged to use a standard scientific referencing format where quotes and statements are referred to in the text and bibliography/references.

Achievement is dependent on how well you **demonstrate your understanding of the physics** involved in the TC-1 seismometer. Where appropriate, you should explain, justify, compare, contrast and justify your explanations and conclusions.

Your report should be structured with headings and a bibliography.

What might a structured report look like?

A report often has these headings:

Title	The physics of a modern seismometer
Purpose	To investigate the physics involved in a modern seismometer
Introduction	Introduces what seismometers are, places them in the context and relates to the purpose.

Discussion
Contains descriptions, illustrations and explanations of the relevant seismometer components such as solenoids, electromagnetic induction, seismic wave forms, harmonic motion, electronic digitisation. etc. This forms the body of the report.

Summary
Valid and connected to the context. Includes justifications of statements and supported by research sources. May include ideas on the limitations of the research information.

Bibliography/Referencing.
Sources of information are alphabetically listed in a traceable format.

Evidence/Judgements for Achievement (Descriptive)

The student:

Identifies and describes the key aspects of the physics related to the TC-1.

Describes how and/or why the physics applies to this context.

Examples of evidence:

Describes the function of each component and identifies how the seismometer works to produce an induced electric current in a coil of wire.

Identifies the need to amplify and convert an electric current into a digital signal that can then be displayed.

Other physics concepts include seismic waves forms (P and S), data logging, signal amplification, vertical pendulum inertia and harmonics

By having sensitive and calibrated seismometers, a better global and local monitoring of earthquakes can be achieved. With networks, epicentre and hypocentres can be determined as well as magnitude. This enables better understanding of seismic waves and the physics and chemistry of the Earth's interior. This impacts on how people can reduce the damage caused by earthquakes.

Makes a connection between how the seismometer works and their application.

Have traceable **sources** of information (2+).

Evidence/Judgements for Achievement with Merit

(In depth explanatory)

The student:

Identifies and describes in depth, the key aspects of the physics related to the TC-1.

Provides reasons of how and/or why the physics applies to this context.

Examples of evidence:

Describes in depth, the function of each component. For example, the suspended magnet induces an electric current in a coil of wire or solenoid. This induced current is translated into a digital signal. Explains how this happens.

E.g. Develops further explanations of seismic wave forms and explains the electronic sensitivities of seismometer signals.

This impacts on the ability of a seismometer to detect wave forms of different amplitudes and frequencies which in turn provides a better understanding of what happens when seismic energy is released and can lead to ideas of magnitude and energy/wave relationships.

Connects the uses of the schools TC1 seismometer to its **physics**.

Evidence/Judgements for Achievement with Excellence (Comprehensive)

The student:

Comprehensively identifies and describes the key aspects of the physics related to the TC-1.

Elaborates how and/or why the physics applies to this context

Justifies why the particular physics is well-suited to this context, and/or compares alternatives.

Examples of evidence:

Demonstrates an understanding of Faradays laws and applies them to electromagnetic induction of the wire coil. The wire coil has a particular number of windings and gauge relative to the field strength of the magnet.

Shows understanding of how the seismometer is based on the principle of a vertical pendulum with a high inertial mass relative to the ground and that when the ground moves the electronic signal produced by electromagnetic induction is amplified by the data logger and translated into a digital signal which is electronically displayed in specially designed software.

Demonstrates connections between how electromagnetic induction can be amplified to enable highly sensitive seismometers which can detect dispersion of seismic energy waves around the globe. This builds a better understanding of the interior and what is beneath our feet where we build.

Connects the uses of the schools TC1 seismometer to its physics and links concepts and ideas.