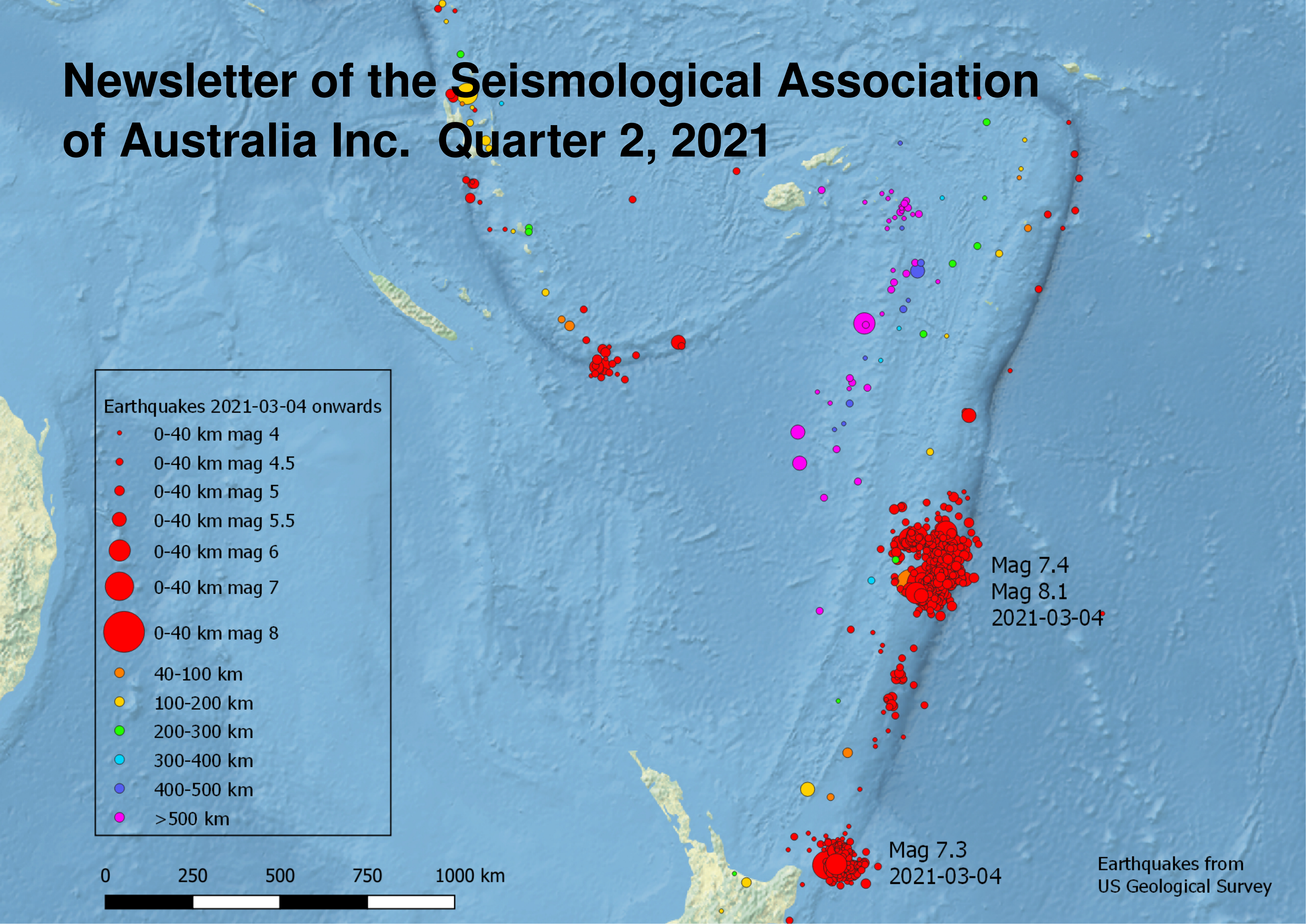
Newsletter of the Seismological Association of Australia Inc. Quarter 2, 2021



Seismological Association of Australia Inc.

Welcome to the Newsletter of the
Seismological Association of Australia Inc.
PO Box 682, Mylor SA 5153

Membership of the SAA is open to all, with the only prerequisite being an interest in seismology. Membership applies for the calendar year. (January through to December)

Membership fees are: Full member $50

A Membership application form can be obtained from the Treasurer by email or you may download it here.

Member Submissions

Submissions for inclusion in the Newsletter are welcome from all members; please note that submissions may be held over for later editions. Wherever possible, text submissions should be sent via email in almost any word processing format. Images should be high resolution and uncompressed, although high resolution JPEGs are acceptable. Your name may be withheld only if requested at the time of submitting.

All enquiries and submissions should be addressed to the Editor and preferably sent by email to weaksignals@iinet.net.au

Your Committee

Chairperson - Blair Lade

mobile: 0407 189 061 email: blairl@bettanet.net.au

Chief Seismologist - David Love

phone: 08 8336 8003 email: david@earthquake.net.au

Public Officer - Paul Hutchinson

mobile: 0419 829 216 email: windfarmer@bigpond.com

Secretary - Joe Grida

mobile: 0407 558 036 email: joe.grida1@bigpond.com.net

Treasurer - Joe Grida

mobile: 0407 558 036 email: joe.grida1@bigpond.com

Committee Member - Kevin McCue

email: mccue.kevin@gmail.com

Editor - Peter Gray

mobile: 0418 829 632 email: weaksignals@iinet.net.au

The SAA can be contacted by post to the address above, or by email to any member of the Committee.

SAA News

Members Meetings - On Monday, April 12th, the second of this year's General Meetings was held via Zoom. The main topics for the meeting were the initial results from the Wobbly Building Project which were discussed briefly and a preliminary report can be found in this edition. The Tonga-Kermadec event from March 4th was also discussed, along with presentations prepared by Paul Summerville, Gary Gibson, David Love & Kevin McCue. These presentations can also be found in this edition.
Members are reminded of upcoming General Meetings via Zoom, the third is to be held on June 14th and the final on August 9th. The 2021 AGM is currently scheduled for October 25th. The previously mentioned "in-person" casual BBQ/working bee at Jim Deer's residence has been scrapped for the forseeable future.

On the Cover - Courtesy of David Love and the USGS, an image of the main quakes and aftershocks for the Tonga-Kermadec event.

The 2018 CQSRG Seismological Report, authored by Mike Turnbull, is now available for download at http://cqsrg.org/reports/

Raspberry Shakes have arrived - The association recently purchased a Raspberry Shake RJAM digitiser from OSOP in Panama and gratefully accepted another RJAM, kindly donated to the SAA by Kevin McCue. Also, Michael Andre Phillips has kindly donated an Raspberry Shake 3D to the SAA. These instruments will be available for seismic monitoring activities in "less conventional seismic settings" where our Kelunji Echo and EchoPro recorders may be inappropriate.

New Waves from SRC - The Seismology Research Centre has just released a new version of their Waves Analysis Software. Waves 4.0 finally brings multi-layer velocity model location algorithms from eqFocus into an interactive graphically interface that's easy to use, and just as easy for students to understand when used as a teaching tool. It includes map-visualised solutions and a simple pointer-based controls to make data analysis fast and efficient.

Vale Randall Peters - Sadly, I wish to inform members of the passing of Professor Randall Peters. His name will never be far from our thoughts, having lent it to The Peters Seismological Observatory (TPSO). News of Randall's death only reached us here in Australia recently and appears to have happened late last year. Our last correspondence with Randall was in October 2020 and addressed to the Secretary as follows:

"Joe, I am so thankful to be a part of SAA Inc., one of the best teams in all of the world. I hope that all of you 'down-under' great friends have been, like myself, spared the torments of the pandemic. When that mess finally clears up adequately, I look forward to our continued influence on the world of seismology. Randall"

SAA's Wobbly Building Project

Kindly submitted by David Love
Chief Seismologist,SAA
and Kevin McCue, CQSRG

The Expected Shaking of Tall Buildings in Adelaide and Perth during a shallow Mega-thrust Earthquake in Indonesia

Introduction

On 19 August 1977 tall buildings in Perth were evacuated following a great shallow Mw 8.3 earthquake off the coast of Sumba, Indonesia 3000km away. Kevin was at Adelaide University watching the seismograph pen (pen and ink recording then) banging from one side of the drum to the other. The phones started ringing as worried staff in a tall building sought advice on whether they should evacuate their shaking building. Minor non-structural damage was reported in Perth tall buildings (Gregson and others, 1978) but no monitoring was (or is) in place in any tall building in Australia to measure its response. Other large earthquakes in Indonesia in 1963 and 1974 caused similar effects to buildings in Perth and Adelaide with reports in Adelaide from upper floors of swinging doors, creaking columns, creaking windows, and slight non-structural cracking.

The question arises as to what will happen when an even greater earthquake occurs on the plate boundary which could generate seismic waves 10 times larger than those of 1977. There are many more and taller buildings in both cities, now, than there were in late 1977.

What do we know about these tall buildings and importantly their foundations to make an assessment of the expected amplitude of shaking? Micro-zoning measurements have been done in both cities and the cause of the shaking can be explained in terms of resonance of the Earth's surface layers. In Adelaide a prominent 1sec or 1Hz resonance was measured in Adelaide and North Adelaide (McCue and Love, 1997) and several 100m deep boreholes encountered unconsolidated and saturated silty sands layers under the limestone which is considered basement for pile foundations. In Perth the ground motion on the unconsolidated sediments of the Perth Basin are some 7.5 times greater than on the Precambrian granite of the Yilgarn Block (Gregson and others). They also noted that the acceleration computed at roof level was about 8 times that on the ground.

A recommendation arising from the Gregson and others study was that accelerographs should be installed in selected buildings in Perth at top, middle and ground levels.

Measuring building response

A triaxial Trillium seismometer and Guralp accelerometer were prepared and installed by SAA members Paul Hutchinson, David Miller, Blair Lade and David Love on Level 11 of a 14 storey building in Adelaide over Easter, 01-06 April 2021.

SAA's Wobbly Building Project

An approximate plan of the building footprint is shown in Figure 1. This is the absolute minimum building monitoring required. One could use another instrument in the basement to compute the relative displacement of top and base of the building, or the next step would be to put an instrument on each floor to measure these and the mode shapes. The results of this short monitoring exercise are quite informative.

In Figure 2b, the fundamental period is 1.95s and at least 7 higher harmonics are clear in the Fourier spectrum of all 6 components but best on the seismometer horizontals in Figure 2a. There is not enough information to say just what the higher harmonics are or indeed whether there are 2 closely spaced peaks near 2sec. being the response in two orthogonal directions which would indicate that the building is indeed quite symmetric in stiffness. The first two peaks are obvious on both channels over a number of examined time spans. The third peak is consistently larger on the EW axis than NS, and the 4th peak is consistently a slightly different frequency on the horizontal axes. Further peaks are not consistent across time spans. The first two peaks are obvious on both channels over a number of examined time spans.
Using AS2121-1979 we would expect the natural period to be 1.4s (=N/10) where N is the number of storeys and damping of 5% is assumed. AS1170.4-1993 uses h/46 where h is the height in metres above the structural base for the more flexible direction and again the damping is assumed to be 5%. The building height is approximately 53m so the period would be 1.15s.

It would be interesting to compare these measured values against those calculated by the design engineers, especially if they undertook a finite element analysis of the building response under earthquake loads.

It is unfortunate that anyone could design and build an expensive building and not test whether it achieves the computed design parameters, especially when it is so quick and easy to measure the natural period and damping, the two parameters used to compute the static earthquake loads.

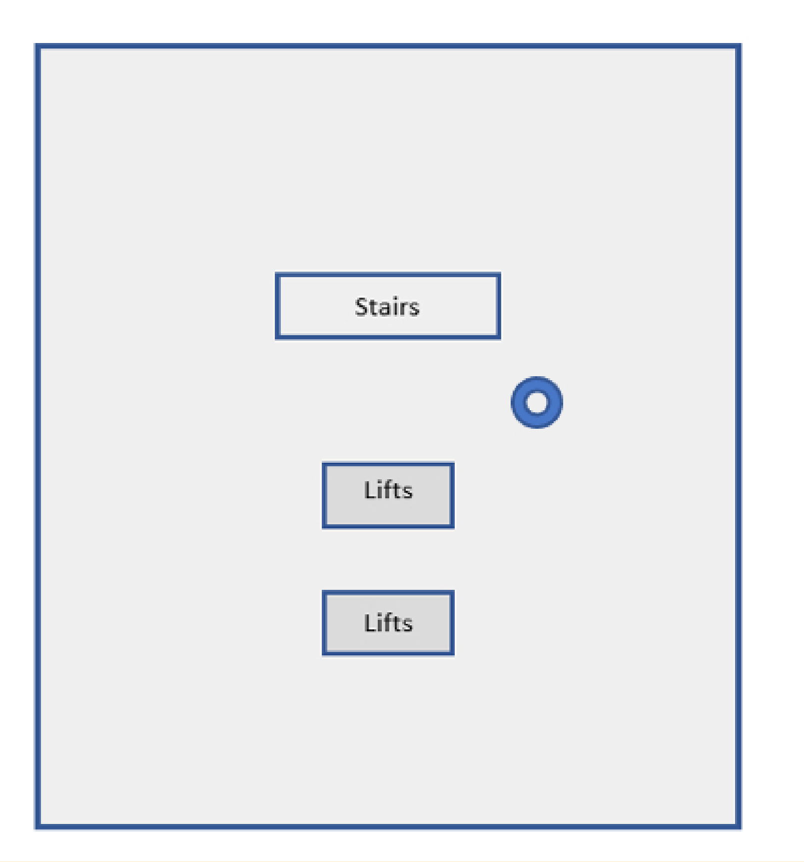


Figure 1. Footprint of measured building and location of sensors.

SAA's Wobbly Building Project

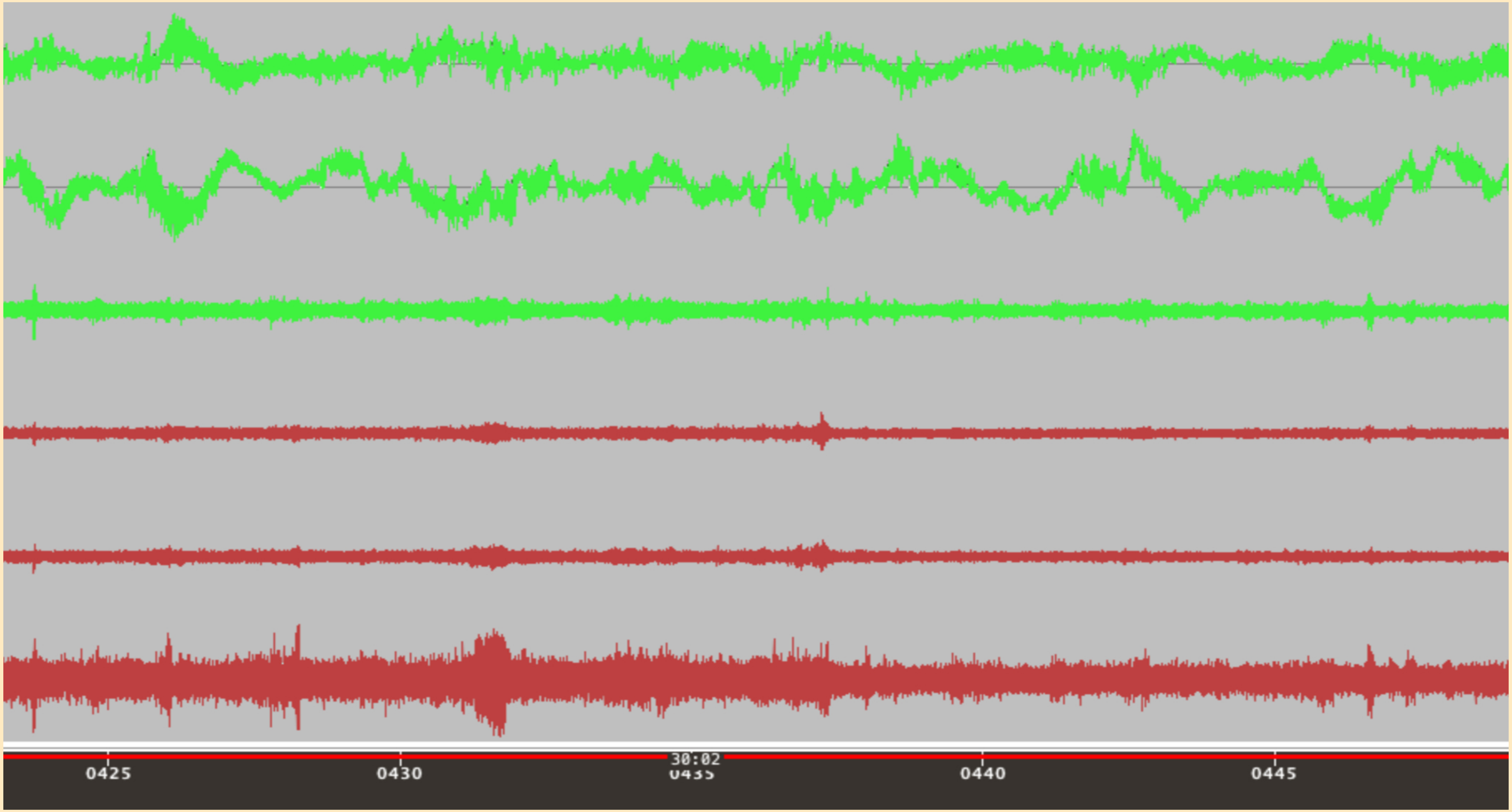


Figure 2a. The seismometer (green) and accelerometer (red) traces for 35 minutes near the time of maximum wind speed.

SAA's Wobbly Building Project

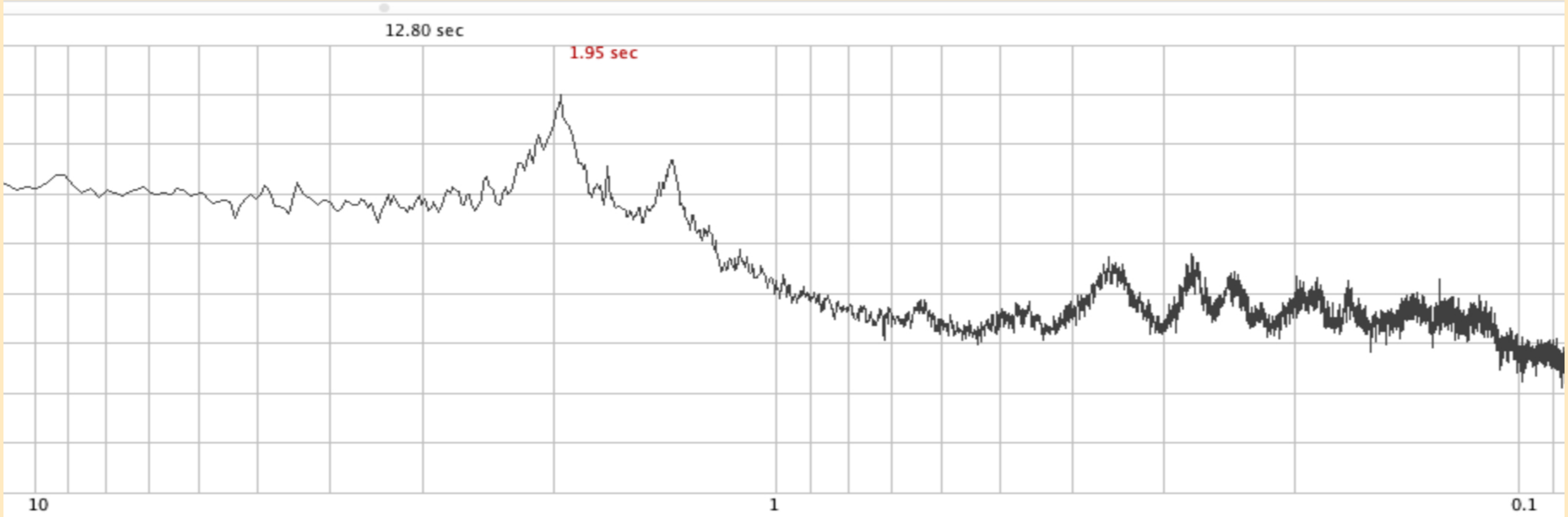


Figure 2b. A Fourier spectrum of the shaded part of the top trace, the abscissae is period in seconds 10, 1.0 and 0.1 marked on a log scale. Peaks are at approximately 1.95s, 1.3s, 0.35s, 0.25s etc.

Recommendation

We recommend that a special study be made of this building to compare and explain the difference between the natural period and damping predicted by the code and the actual measured values. We also recommend the permanent monitoring of several select tall buildings in Adelaide and Perth to capture their response during the next great earthquake in Indonesia.

References

P.J. Gregson, E.P. Paull, & B.A. Gaull 1978. The Indonesian earthquake of 19 August 1977, effects in Western Australia. BMR J., Aust Geol & Geophys., 4 (2) pp. 135-140.

McCue K.F., and Love, D., 1997 — Earthquake Microzonation: Adelaide South Australia, Report and CD for EMA (unpbl.)

A Mathematical Paradox

Kindly submitted by Mike Turnbull
Lead Seismologist, Central Queensland Seismology Research Group (CQSRG)

The consequences of $0.\dot{9}$ being numerically equivalent to 1.0

An Initial Proof.
For a long time it has been asserted that $0.\dot{9}$ is numerically equal to 1.0. There are two ways to prove this assertion.

Proof by algebra.
We aim to prove that: $0.\dot{9}=1.0$ ***Principal Assertion***

We start with the assertion that: $x=0.\dot{9}$ ***Equation 1.1***

Therefore: $10x=9.\dot{9}$ ***Equation 1.2***

By subtracting the left-hand side of Equation 1.1 from the left-hand side of Equation 1.2 we get:

$10x-x=9x$ ***Equation 1.3***

By subtracting the right-hand side of Equation 1.1 from the right-hand side of Equation 1.2 we get:

$9.\dot{9}-0.\dot{9}=9.0$ ***Equation 1.4***

Therefore, by logical deduction from comparison of Equation 1.3 and Equation 1.4:

$9x=9.0$ ***Equation 1.5***

Dividing each side of Equation 1.5 by 9 we get: $x=1.0$ ***Equation 1.6***

Therefore, from Equation 1.1 and Equation 1.6: $0.\dot{9}=1.0$ ***Equation 1.7***

Q.E.D.

A Mathematical Paradox

The consequences of $0.\dot{9}$ being numerically equivalent to 1.0

Proof by Fractional Addition.

We aim to prove that:

$$0.\dot{9}=1.0 \qquad \textit{Principal Assertion}$$

$$\frac{1}{3}=0.\dot{3} \qquad \textit{Equation 2.1}$$

$$\frac{2}{3}=0.\dot{6} \qquad \textit{Equation 2.2}$$

Adding the left-hand sides of Equation 2.1 and 2.2 we get:

$$\frac{1}{3}+\frac{2}{3}=\frac{3}{3}=1 \qquad \textit{Equation 2.3}$$

Adding the right-hand sides of Equation 2.1 and 2.2 we get::

$$0.\dot{3}+0.\dot{6}=0.\dot{9} \qquad \textit{Equation 2.4}$$

Therefore, by logical deduction from comparison of Equation 2.3 and Equation 2.4:

$$0.\dot{9}=1.0 \qquad \textit{Equation 2.5}$$

Q.E.D.

A Mathematical Paradox

The consequences of $0.\dot{9}$ being numerically equivalent to 1.0

The Paradox that Leads on from the Initial Proof.

From Equations 1.7 and 2.5 we see that: $0.\dot{9}=1.0$ ***Equation 3.1***

Subtracting $0.\dot{1}$ from the left-hand side of Equation 3.1 gives: $0.\dot{9}-0.\dot{1}=0.\dot{8}$ ***Equation 3.2***

Subtracting $0.\dot{1}$ from the right-hand side of Equation 3.1 gives: $1.0-0.\dot{1}=0.\dot{9}$ ***Equation 3.3***

Now, Equations 3.2 and 3.3 are implying that: $0.\dot{1}\neq 0.0$ ***Equation 3.4***

And, Equation 3.1 is asserting that: $0.\dot{1}=0.0$ ***Equation 3.5***

But Equations 3.4 and 3.5 are inconsistent – both cannot be true!

A Mathematical Paradox

The consequences of $0.\dot{9}$ being numerically equivalent to 1.0

The Consequence that Flows from the Paradox

Acceptance of the validity of the initial proof inevitably leads to mathematical inconsistencies. The paradox presented above is but one of an infinite number of similar inconsistencies. Therefore, the validity of the initial proof is unsound and must be rejected.

This consequence is also an assertion that an infinitely recurring decimal fraction can never be exactly equivalent to its rational fractional representation, for example:

$$\frac{1}{3} \neq 0.\dot{3}$$

And:

$$\frac{2}{3} \neq 0.\dot{6}$$

Simply because infinity is a concept, not a numerical value!

However, there are many very qualified people who will assert that infinity is indeed a number! There are some who will assert that it is a negative number! (and some who will assert it is a positive number).
A brief search of Dr Google will reveal the arguments the concept elicits.

This is a very active area of theoretical mathematics – and perhaps a resolution of the paradox will help us understand what goes on inside black holes.

TONGA-KERMADEC EVENT

Kindly submitted by Kevin McCue, mainly from information on the US Geological Survey website.

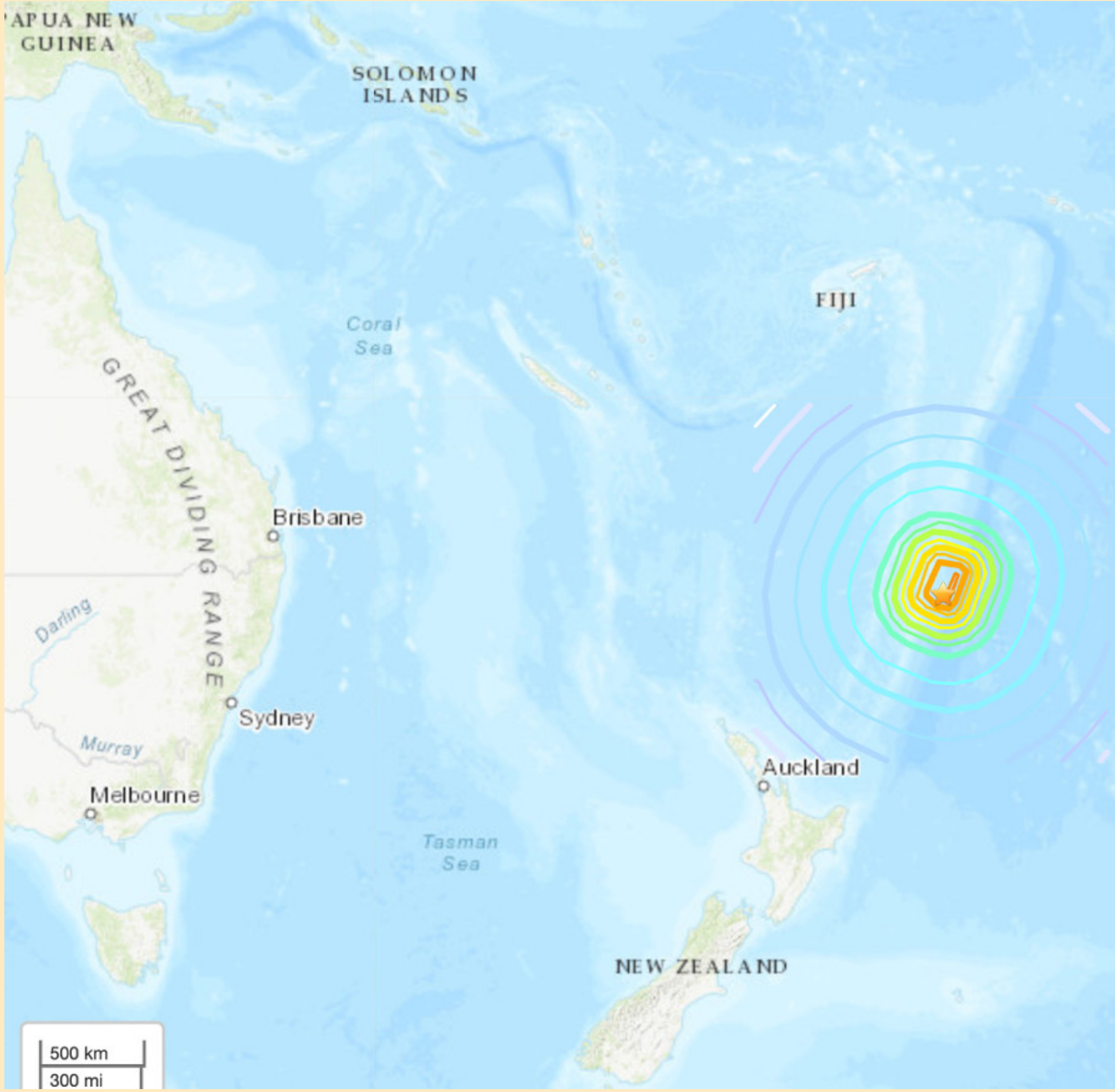
Tectonic Summary
The 4 March 2021 at 19:28 UTC M 8.1 earthquake near the Kermadec Islands, New Zealand was by reverse faulting on the Tonga-Kermadec subduction zone. Subduction extends NNE from the North Island of New Zealand for more than 2,500 km through Tonga to within 100 km of Samoa.

Focal mechanism solutions for the event indicate rupture occurred as a result of reverse faulting, either by low angle thrust motion on a west-dipping fault or by high angle reverse motion on a near vertical fault. The location, depth, and style of faulting are consistent with the earthquake having occurred on or near the west-dipping subducting plate interface between the Pacific and Australia plates.

A M 7.4 thrust foreshock preceded the main earthquake by 107 minutes. It was located ~50 km west of the mainshock. In terms of seismic moment, the M 8.1 was ~11 x larger than the M 7.4 foreshock.

At the location of the earthquake, the Pacific plate subducts westward relative to the Australia plate at the Tonga and Kermadec Trenches at a velocity of about 60 mm/yr.

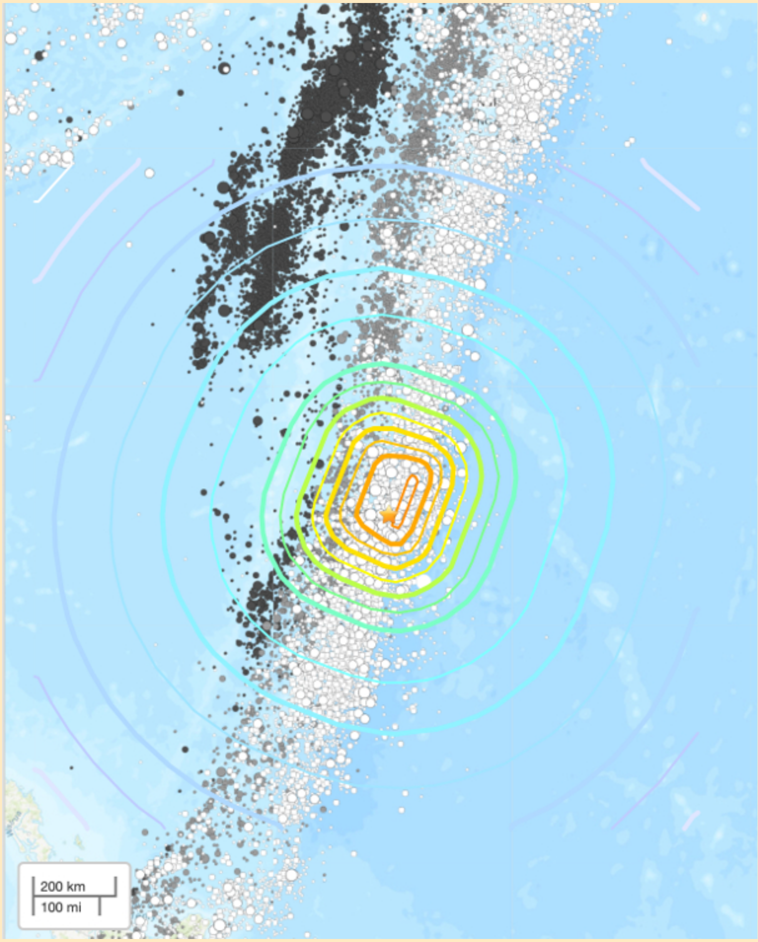
Reverse events of the size of the March 4 earthquake are typically about 175 km long x 75 km wide.



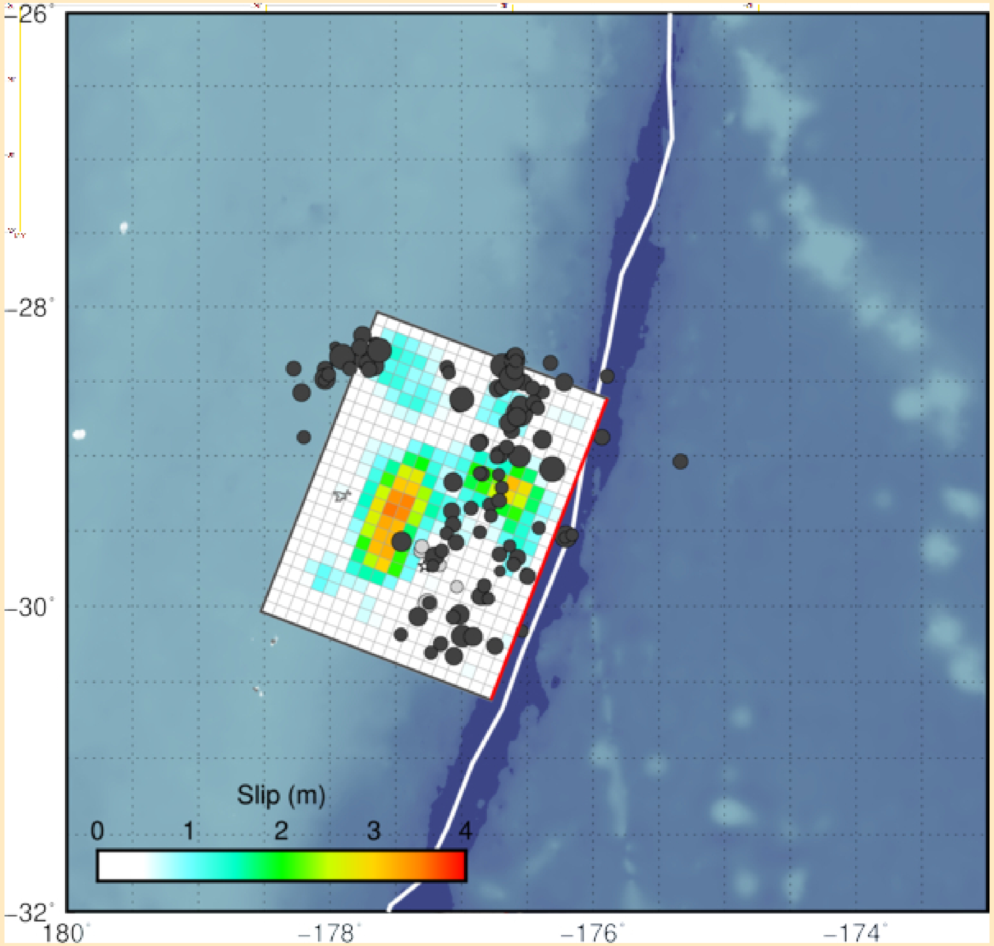
Location of mainshock and area probably affected by shaking

TONGA-KERMADEC EVENT

The interaction between the Pacific and Australia plates creates one of the more seismically active tectonic environments in the world. In the past century, 215 earthquakes >M 6 have occurred within 250 km of the M 8.1 earthquake, including the M 7.4 that occurred ~107 minutes prior. The largest previous event was a M 8 earthquake in January 1976, more than 100 km to the north, with no associated casualties or damage.



Historical earthquakes; deep events black, shallow events white



Estimated rupture area with up to 3.5 m of movement in one area

TONGA-KERMADEC EVENT

M 8.1 - Kermadec Islands, New Zealand

2021-03-04 19:28:33 (UTC) | 29.723°S 177.279°W | 28.9 km depth

Moment Tensor

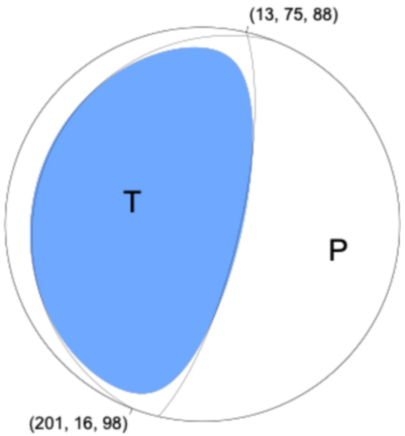
View all moment-tensor products (1 total)

Contributed by US 4 last updated 2021-03-25 14:27:57 (UTC)

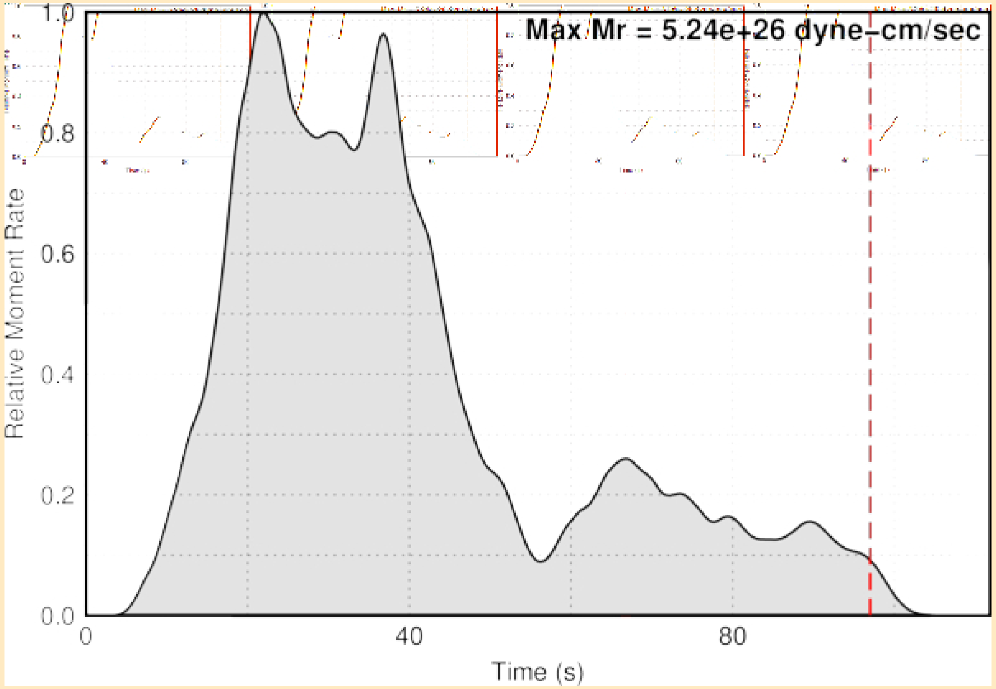
✓ The data below are the most preferred data available
✓ The data below have been reviewed by a scientist

W-phase Moment Tensor (Mww)

Moment	2.033e+21 N-m
Magnitude	8.14 Mww
Depth	23.5 km
Percent DC	89%
Half Duration	36.44 s
Catalog	US
Data Source	US 4
Contributor	US 4



Mechanism of the earthquake, most likely on a shallow dipping plane to WNW



Most of the rupture occurred over a period of 40 secs

The Pacific Tsunami Warning Centre issued alerts for parts of New Zealand, Norfolk Island, American Samoa and Hawaii. New Zealand's National Emergency Management Agency ordered people near the coast in the warning areas to "MOVE IMMEDIATELY to the nearest high ground, out of all tsunami evacuation zones, or as far inland as possible."

Small tsunami waves were recorded in Vanuatu, Tonga and other South Pacific nations. You can watch the arrival of several waves at Tokomaru Bay, NZ by following this YouTube link.

TONGA-KERMADEC EVENT

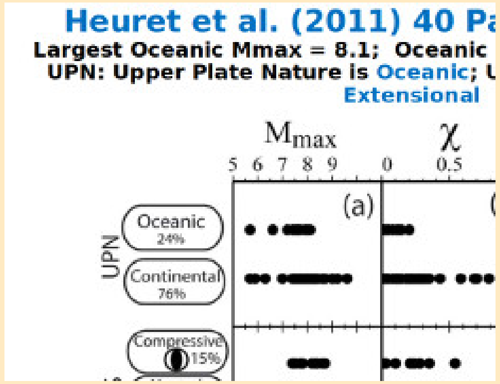
What tsunami risk would a similar or larger earthquake pose to the east coast of Australia? The question was raised a couple of days after the Tonga-Kermadec event at an SAA Committee meeting. The SAA General Meeting via ZOOM to be held on April 12th would be largely dedicated to trying to determine an answer.

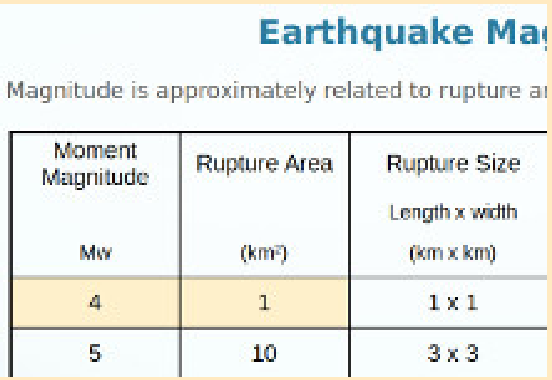
Invitations to present were sent to and accepted by:

Dr Paul Somerville, Principal Seismologist - AECOM, Los Angeles USA

Paul noted that maximum magnitude was not very important for ground motion hazard, but very important for tsunami hazard. Slide 5 shows that peak acceleration does not continue to increase at the same rate with increasing magnitude. Paul reviewed a number of studies on maximum magnitude. One key factor was that oceanic crust on both sides of an interface indicated that a magnitude above M8.5 was unlikely.

To view Paul's presentation to the SAA General Meeting, click the image to the right




Magnitude is approximately related to rupture

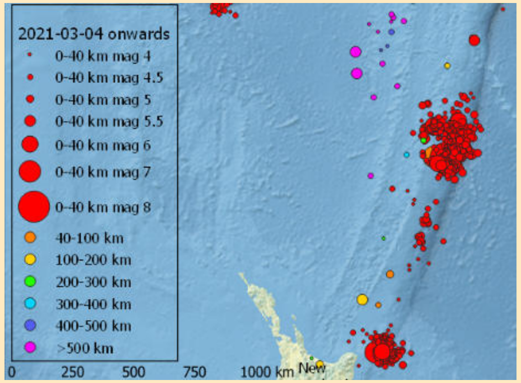
Moment Magnitude Mw	Rupture Area (km²)	Rupture Size Length x width (km x km)
4	1	1 x 1
5	10	3 x 3

Gary Gibson, Principal Research Fellow - University of Melbourne and Senior Seismologist - ES&S, Victoria

Slide 2 is an excellent teaching tool to grasp the effects of small and large earthquakes. Slide 18 (look at green line), using data from 62,683 earthquakes in the Tonga Kermadec region suggests that an event above M8.5 is unlikely.

To view Gary's presentation to the SAA General Meeting, click the image to the left

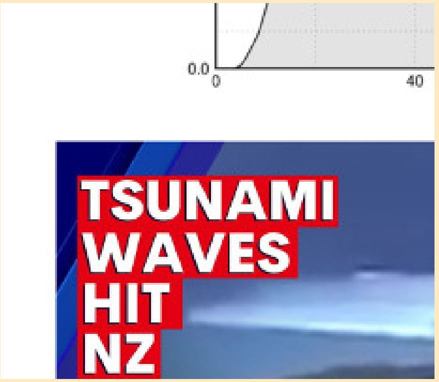
TONGA-KERMADEC EVENT



David Love, Chief Seismologist - Seismological Association of Australia

David plotted maps of earthquakes in the Tonga Kermadec trench for various time spans, with data from the US Geological Survey and Gary's catalogue.

To view David's presentation to the SAA General Meeting, click the image to the right



Kevin McCue, Oversighting Seismologist - Central Queensland Seismology Research Group

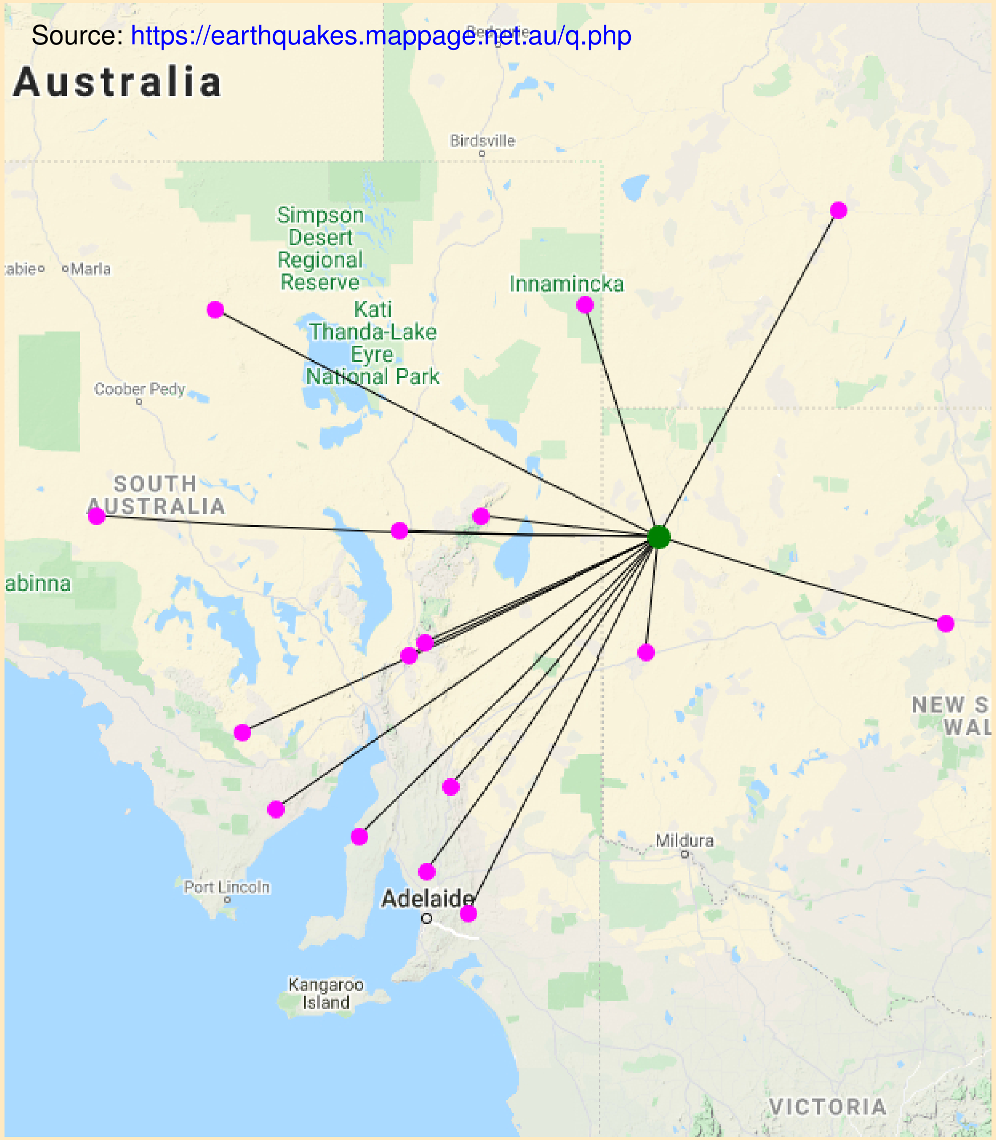
Kevin collated information from the US Geological Survey website.

To view Kevin's original presentation to the SAA General Meeting, click the image to the left

Recent Seismic Activity - New South Wales

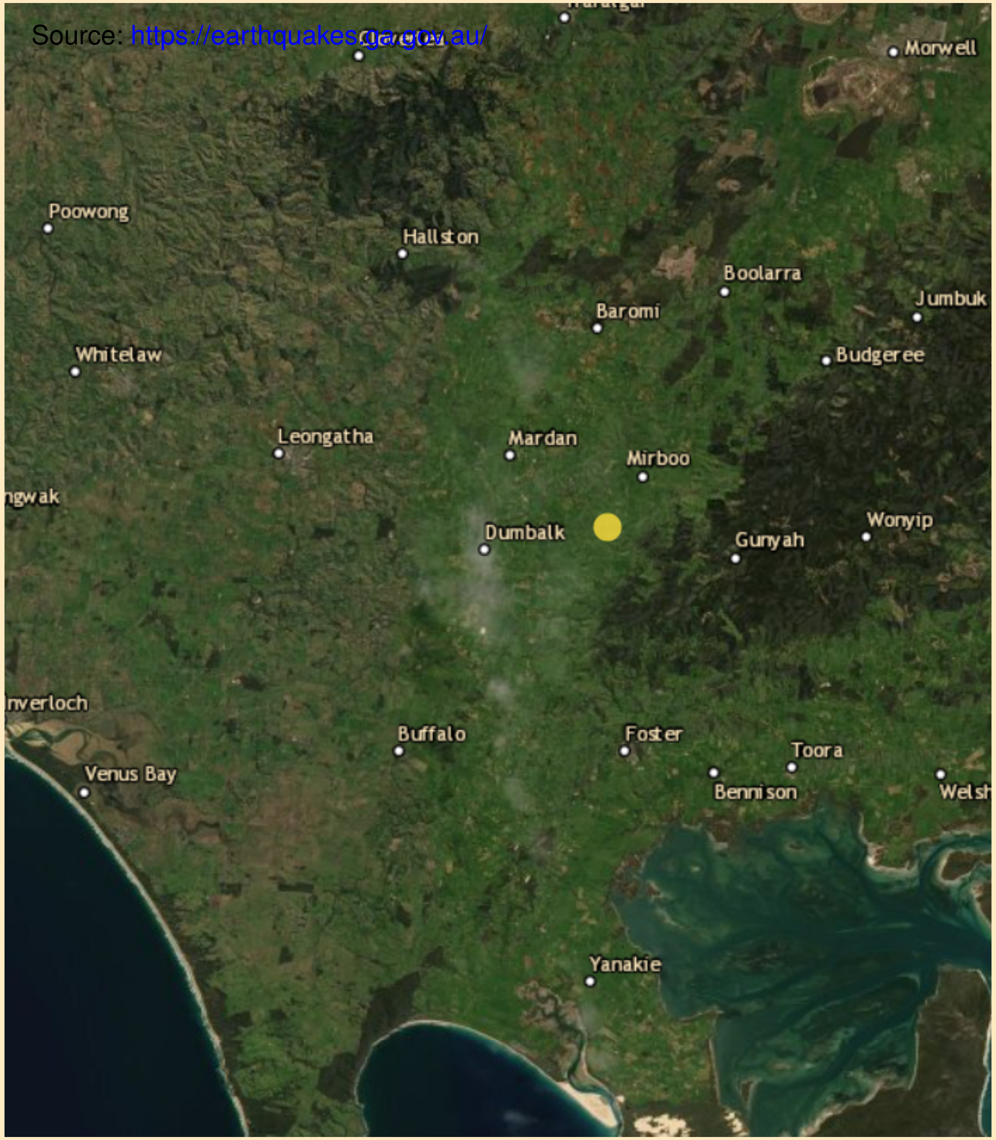
2021-03-29 17:42 SW of Muswellbrook -32.36, 150.87 3.0ML

2021-04-02 22:23 Strzelecki Desert -305274, 141.778 3.0MLv

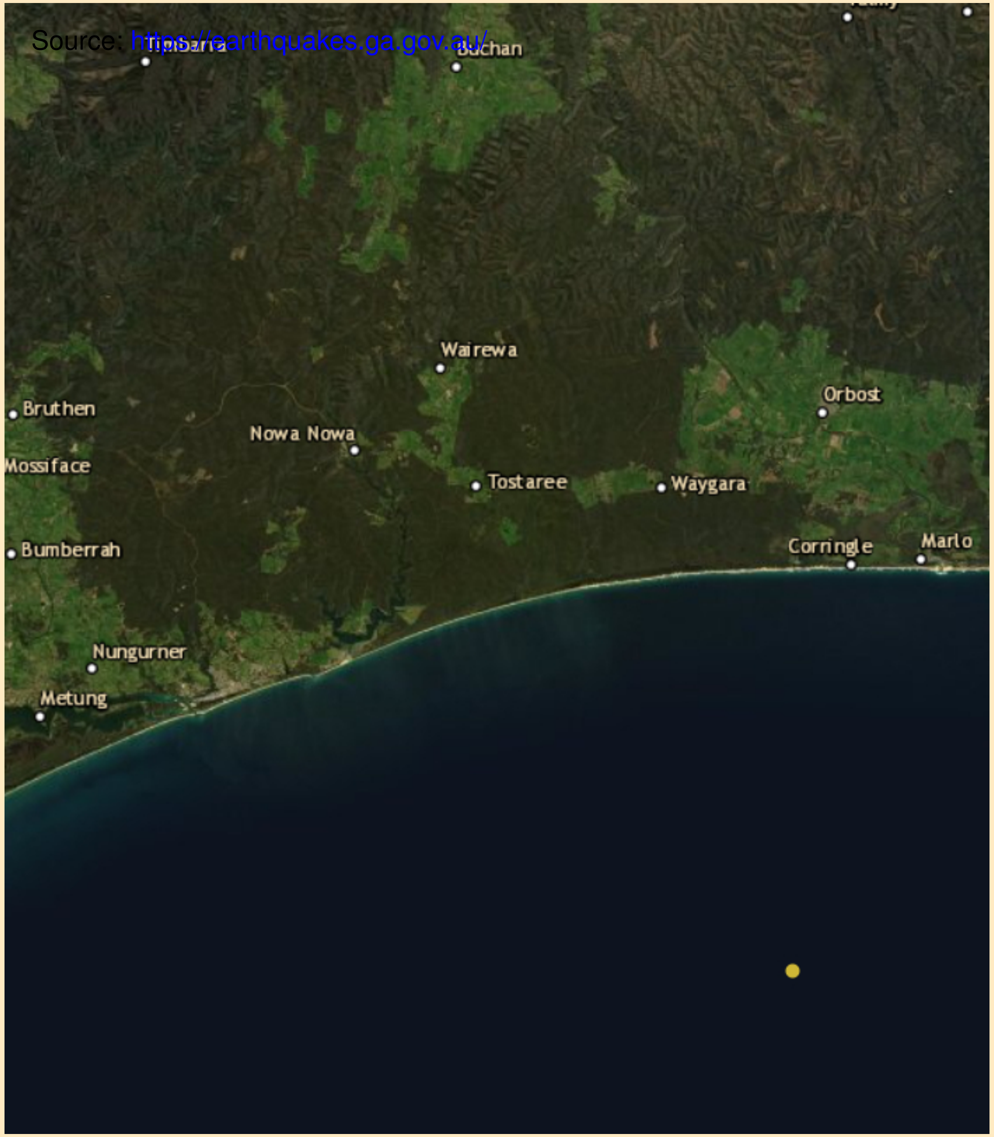


Recent Seismic Activity - Victoria

2021-04-15 14:24 N of Foster -38.52, 146.19 3.0ML

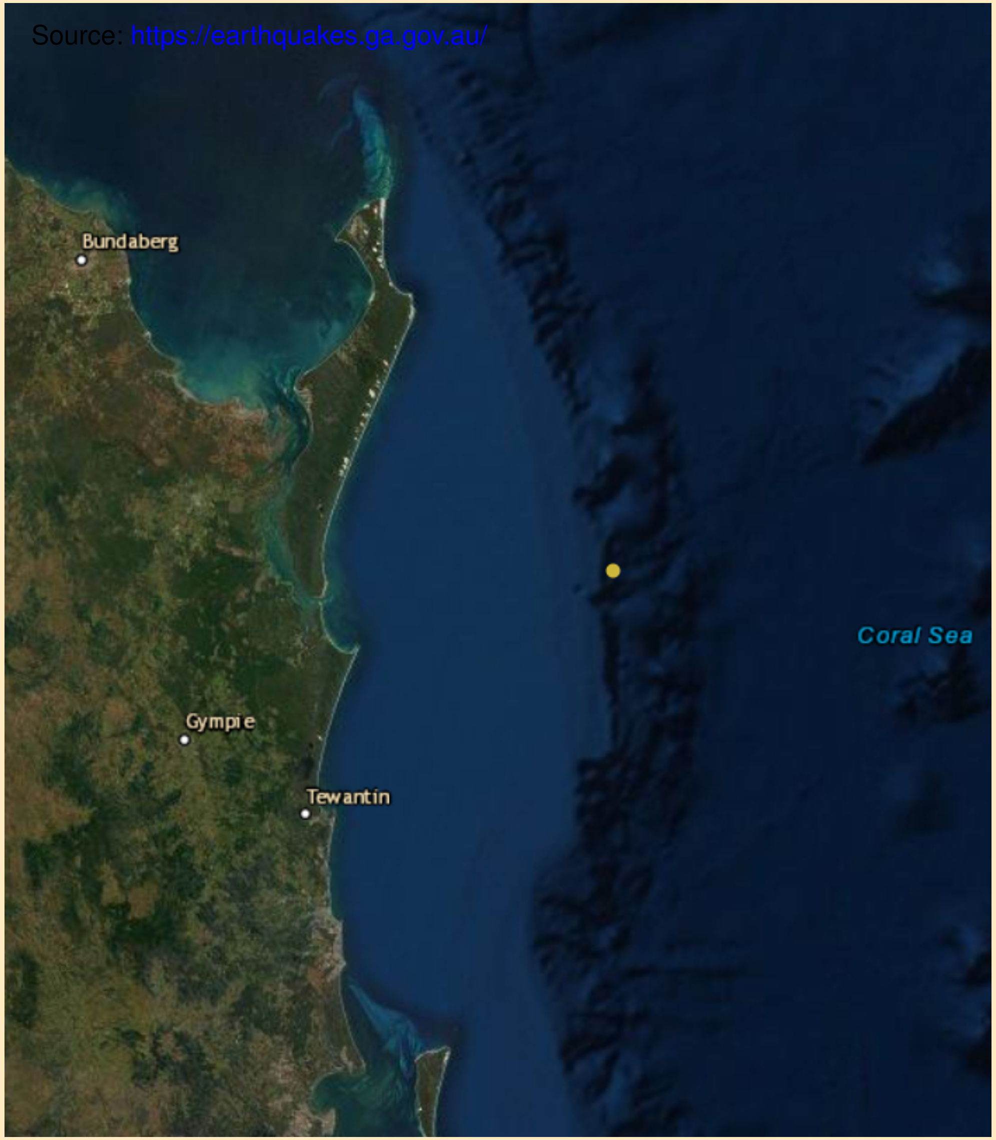


2021-01-25 20:51 N of Balmoral -37.12, 141.86 2.3ML



Recent Seismic Activity - Queensland

2021-03-05 19:25 Offshore Sunshine Coast -25.72, 153.96 2.8ML

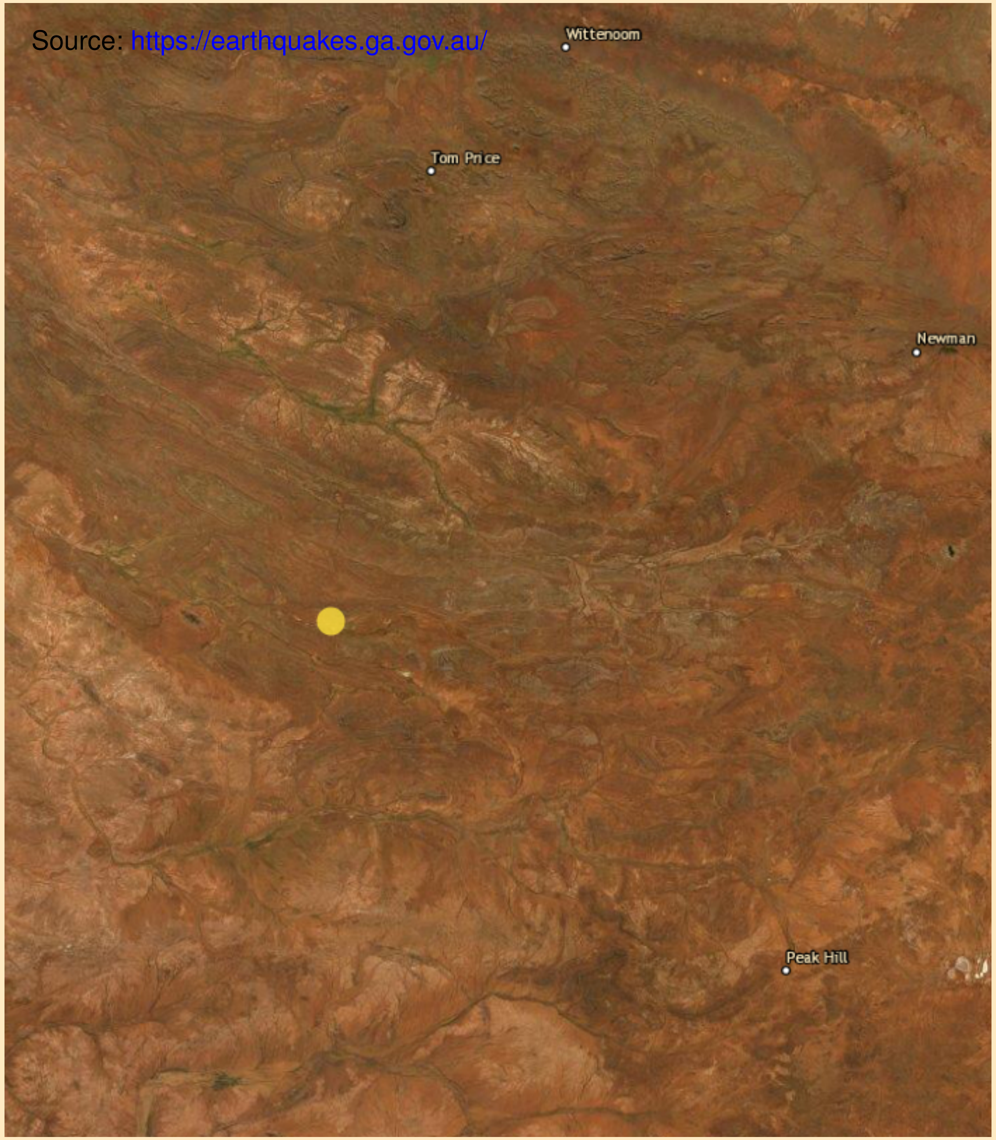


Sadly, there wasn't much in the way of seismic events to choose from in Queensland and none in Tasmania, from the middle of February to the end of May.
Not according to Geoscience Australia's website anyway.

So if you have felt, detected, recorded an event in your region (anywhere in Australia) I'm looking for info on two sizable quakes that have occured in each state since the last SAA Newsletter. The best reported will be published in the following edition. You can get an idea of what's important from the images on these pages - event date/time in UTC, location coordinates and magnitude. If possible, please identify the stations used to determine the hypocentre of the earthquake.

Recent Seismic Activity - Western Australia

2021-04-22 20:54 N of Waldberg -24.34, 117.39 3.1ML

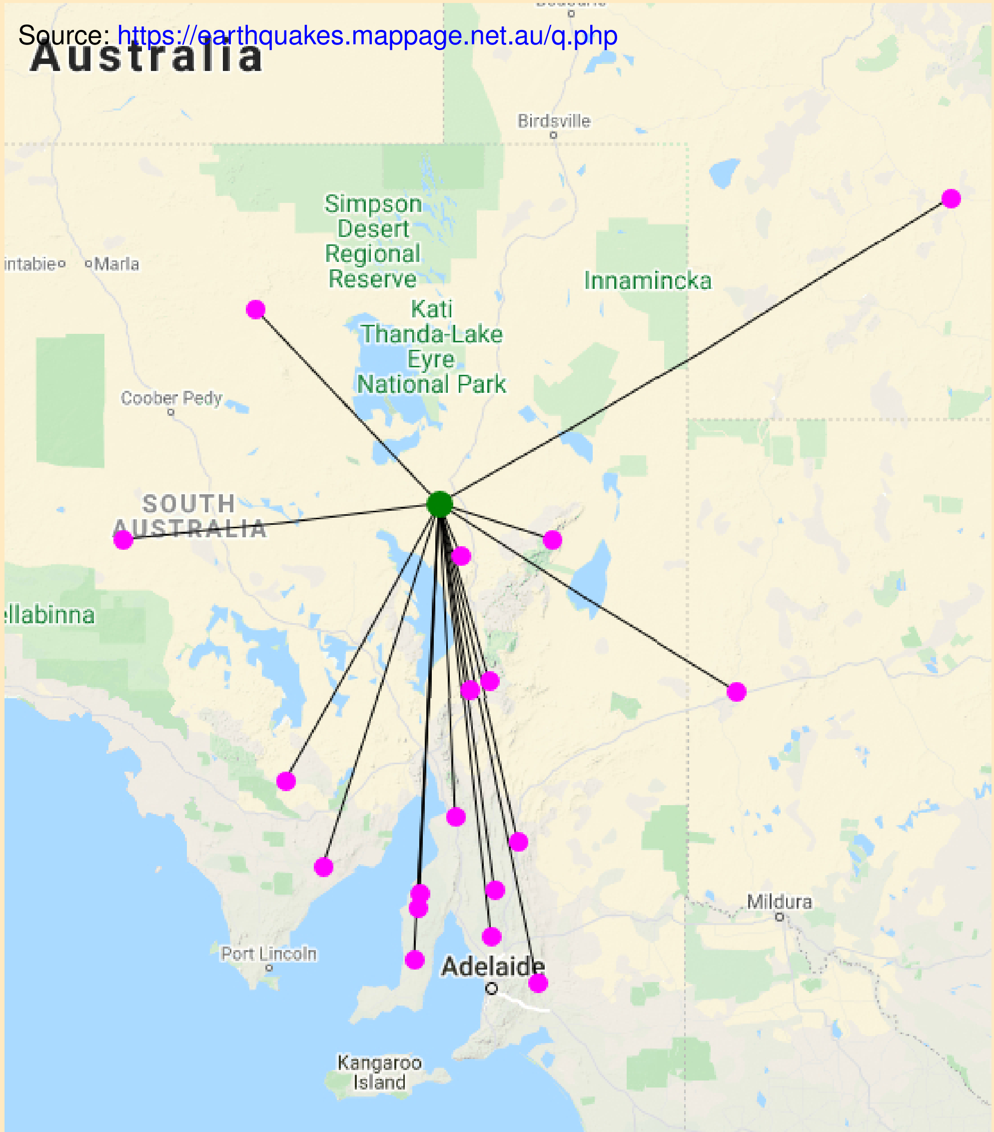


2021-04-18 07:29 SW of Korda -30.96, 117.36 2.7ML

Recent Seismic Activity - South Australia

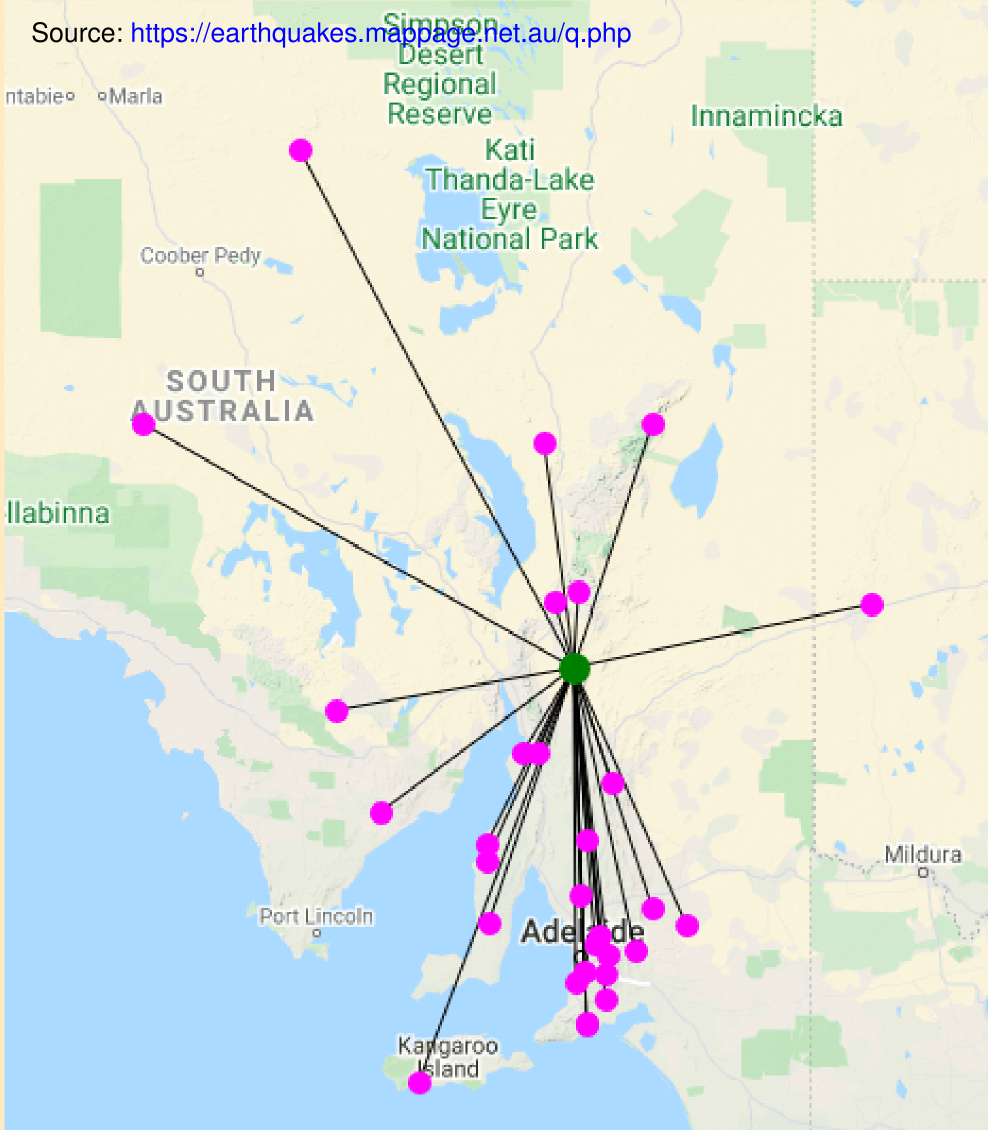
2021-04-15 09:52 Maree -29.9018, 137.954 3.6MLv

Source: https://earthquakes.mappage.net.au/q.php



2021-04-20 12:26 Carrieton -32.4277, 138.524 2.9MLv

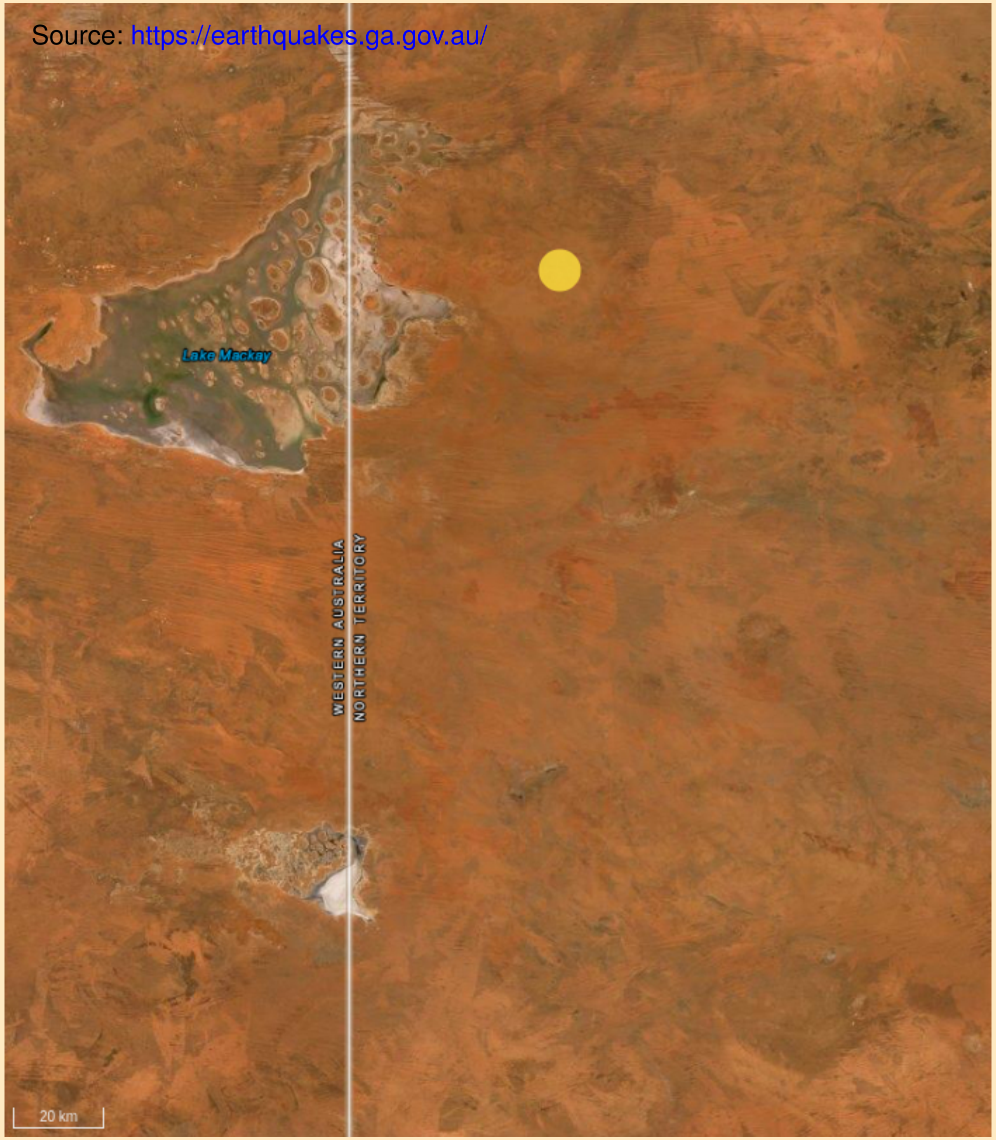
Source: https://earthquakes.mappage.net.au/q.php



Seismological Association of Australia Inc.

Recent Seismic Activity - Northern Territory

2021-03-12 13:57 Great Sandy Desert -22.30, 129.45 4.2ML



2021-02-15 12:54 Surveyor General's Corner -25.42, 129.42 2.9ML

Resources & useful links

Description	URL / Webpage	Notes
SAA Membership Application	https://www.assa.org.au/media/74629/saa-membership-	Join up with the SAA using this form
SAA Flier	https://www.assa.org.au/media/74629/saa-membership-	Our current brochure - flier, saying what we do
SAA Newsletters	https://www.assa.org.au/resources/seismology/saa-	Download any SAA Newsletter from this site
SAA EqServer	http://ade-eqserver.dyndns.org:8080/eqserver/	South Australian miniseed seismometers
Melbourne University EqServer	http://meiproc.earthsci.unimelb.edu.au/eqserver/	Australian miniseed seismometers
Regional Seismic Network	http://www.regional-seismic.net/	PSN seismometers - Aust. Centre for Geomechanics
Australian Public Seismic Network	http://cqsrg.org/psn/stations/	Australian PSN seismometers
Recent SA Earthquakes	https://earthquakes.mappage.net.au/q.php	Data & summaries of recent SA quakes
Central QLD Seismology Research Group	http://www.cqsrg.org/	CQSRG - Kevin McCue
Astronomical Society of SA	https://www.assa.org.au/resources/seismology/	ASSA - Seismology page
Geoscience Australia	http://www.ga.gov.au/earthquakes/initRecentQuakes.do	Our national authority on seismic events
Earthquake Services	https://www.researchgate.net/profile/Colin_Lynam	Citizen Science Consultant - Col Lynam
Seismic Research Centre	https://www.src.com.au/	OEM of seismic instruments & software
symCDC	http://symcdc.com/	OEM of seismic instruments & software
IRIS Seismic Monitor	http://ds.iris.edu/seismon/	Global seismic events
Joint Australian Tsunami Warning Centre	http://www.bom.gov.au/tsunami/	Bureau of Meteorology site
Australian Earthquake Engineers Society	https://aees.org.au/	An organisation with similar interests
Atlas of the Underworld	http://www.atlas-of-the-underworld.org/	Mapping the Earth's mantle
Atlas of Living Australia	https://www.ala.org.au/	A Citizen Science initiative