Seismological Association of Australia Inc.

# SAA Newsletter

The Peismo
**#2/2026**

**From the Editors -** Members are encouraged to submit articles with an earthquake connection of interest to members but accepting they may be edited or not published, at the discretion of the editors. Contributions to: mccue.kevin@gmail.com

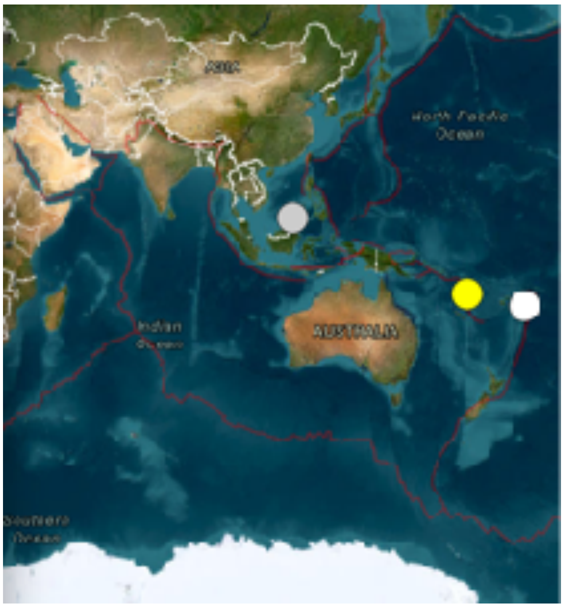
## Contents

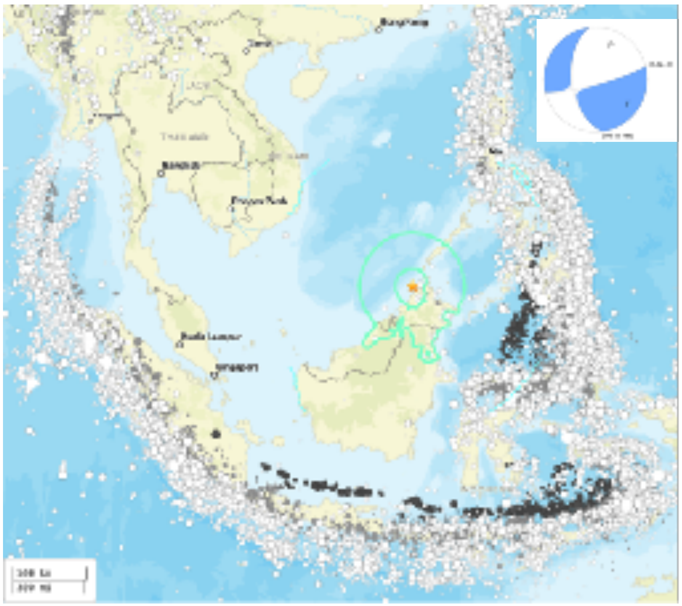


Correction from Editor. My sincere apologies to Diane and Kristin for misspelling their names in the Obituary for Ian Ripper last Newsletter.

### Major Earthquakes Worldwide, January - March 2026, USGS

| Date UTC | Time UTC | Latitude | Longitude | Depth km | Mww | Place |
|---|---|---|---|---|---|---|
| 2026-02-22 | 16:57:46 | 6.83 | 116.26 | 610 | 7.1 | Borneo |
| 2026-03-24 | 04:37:50 | -18.70 | -175.44 | 235 | 7.6 | Tonga |
| 2026-03-30 | 08:44:08 | 15.30 | 167.40 | 115 | 7.3 | Vanuatu |



**Figures 1, 2** The Earth's three major earthquakes in the first quarter of 2026 were the average quarterly expected numbers of major earthquakes except that they were of intermediate depth or deep. The earthquakes under Tonga and Vanuatu were textbook but that under Borneo is puzzling, not easily explicable in a Plate Tectonic model.

On average the earth experiences one earthquake per month of magnitude 7 or more and one earthquake per year of magnitude 8 or more. In the first quarter of 2026, there were three major earthquakes, unusually, none were shallow. The epicentre of the deep earthquake NE Brunei on 22 February is about the same distance from other deep earthquakes to the east as it is deep (Figure 2 from the USGS) i.e. not on a known plate boundary. Shaking was felt on Sabah's west coast and in Sarawak. One Sarawak resident in Miri said he was woken from sleep. A Kota Kinabalu resident initially thought he was feeling faint but subsequently realised it was a tremor. Citizens of Singapore said they felt the tremors. One said it was one of the strongest he had ever felt in Singapore. Others reported just a bit of a shake.

Rather exotic models are being postulated to explain its isolated occurrence and non-compliance with plate-tectonics. The focal mechanism doesn't help.

The deep earthquake under Tonga in the Southwest Pacific, is not very newsworthy, too far from the surface to cause damage, it is on the well-known subduction zone between Samoa and New Zealand. It was felt quite strongly in Tonga. The officer in charge of the group for the environment and disaster ministry, Lucy Faanunu, reported that she was driving at the time and it was shaking the steering wheel left, right, left right.

RNZ Pacific's correspondent in Nuku'alofa Kalafi Moala said he had experienced many quakes in Tonga but this one felt different. *This was a long one. Probably the longest I have experienced here. And now the sirens are going and there's announcements that people should quickly evacuate to higher ground.*

The tsunami warning was soon cancelled.

## Australian earthquakes ML≥3, January-March 2026 (Maps by Clive Collins)

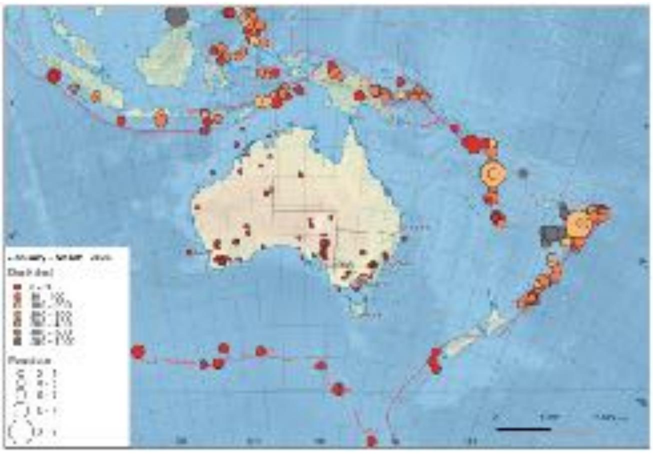


**Figure 3** *Australia in its Plate Tectonic setting.*

The plate boundaries around continental Australia, the thin red solid lines in Figure 3, are the USGS version. We have plotted everything above ~M4.5 on the plate boundary but above M3 in continental Australia, Figure 6, for January to March 2026. These limits are about what is practicable with the existing network.

The plate boundaries around Australia are marked by shallow earthquake epicentres. There were the usual earthquakes in Papua New Guinea and Indonesia and enough on the Australian/Antarctic plate boundary south of Australia to mark it.

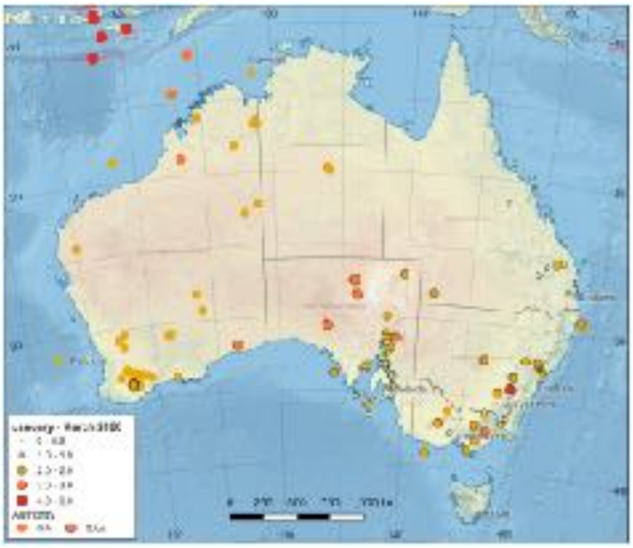


**Figure 4** *Australian earthquakes, Jan-Mar 2026*

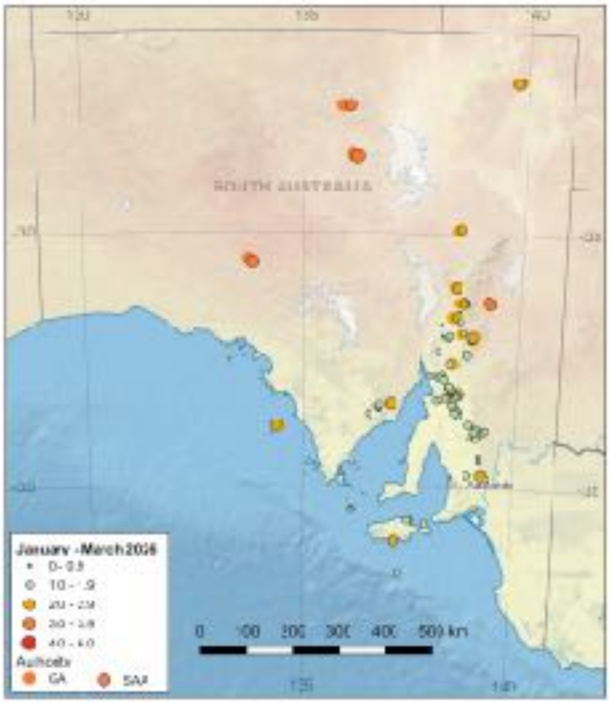


**Figure 5** *SA earthquakes, Jan-Mar 2026*

Seismologists located 27 earthquakes in Australia of magnitude 3 or more, an event in every state or territory bar Queensland and the ACT. The largest, in NSW, M4.5, occurred near Boorowa (see article below). No other M4+ earthquakes were recorded.

## The Boorowa NSW earthquake of 11 March 2026

The mid-crustal magnitude 4.5 earthquake occurred at 7:08pm local time. More than 7400 people reported to GA that they felt the earthquake, from southern NSW and throughout Canberra. During the incident, chandeliers shook at the National Press Club in Barton while University of Canberra vice-chancellor Bill Shorten was delivering a lecture.The editor, Kevin McCue in Aranda, quietly watching the news on the ABC, didn’t feel it but his sister messaged saying their building in Campbell shook.

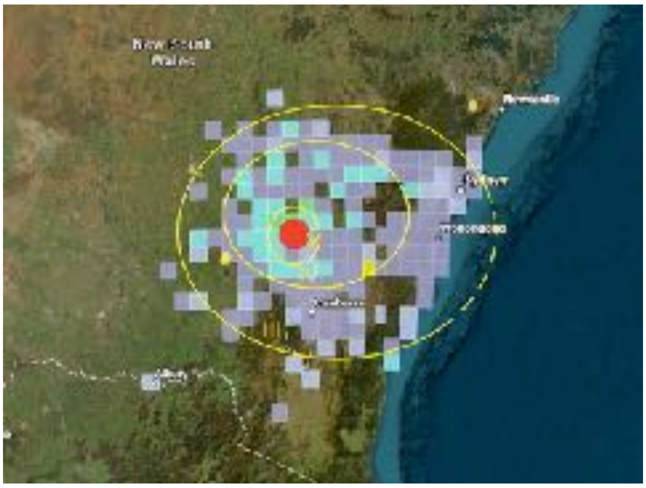


**Figure 6** *Felt reports mapped by GA with Editor's interpreted isoseismal lines (yellow) superimposed*

Reports to GA came from across Central New South Wales, Grenfell, Cowra, Young, Forbes and Parkes, Sydney, Wollongong and Canberra. Seismologist Al Sheehan in Oberon reported: *I was sitting at my computer processing ultrasonic bat calls at the time. I heard and felt a deep rumble. At first I thought it was a vibrating road roller (our neighbour has just recently resurfaced all their roads and pathways ready for an open garden day), but I very quickly realised what it was because the intensity grew and receded. It only lasted a couple of seconds. I didn't notice anything audibly rattling, but the vibration was definitely felt as well as heard.*

*I immediately checked DataView on my Raspberry Shake (R21C0) and there was a beautiful signal, not REAL close by the P-S interval so I was excited it was of a significant size to be felt like that. So I stopped processing bat calls, and fired up the seismology software and started responding to locals who all wanted to know if "my gadget" felt it. Of course I had to wait an hour to access any Raspberry Shake data though their FDSN server, but downloaded some data from other station in the meantime in preparation to having a crack at locating it in Waves.*

The earthquake was recorded on a number of triaxial accelerographs run by GA (YNG, DLN and PHB thanks Michelle and Hugh) and SAA (RNDA). Measurements of ground acceleration from other regional earthquakes is also plotted with the Boorowa earthquake data. The scatter in the horizontal ground motion is large but a trend obvious, the blue dots the pga on Boorowa earthquake recordings, the green dots from a smaller ML4 earthquake near Eugowra NSW in 1994 (Gibson and others, AEES conference, Nov 1994) and the orange dots an earthquake near Oolong NSW in 1984 (McCue, 1984, BMR Report 284).

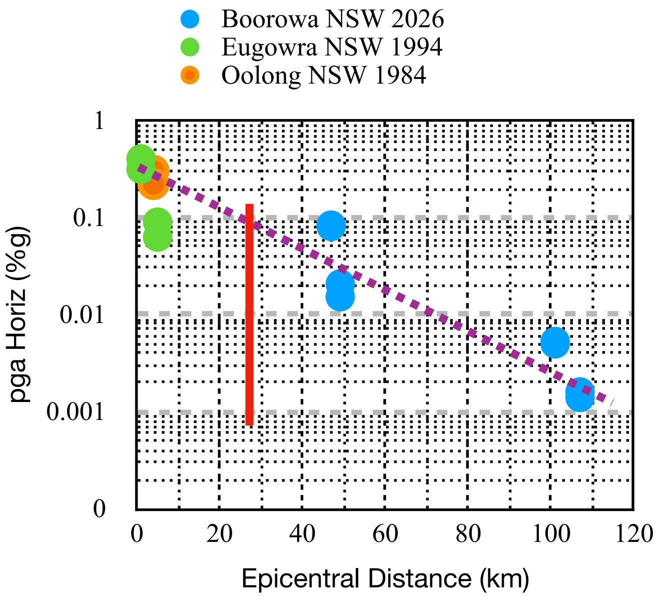



**Figure 7** *A plot of pga vs. epicentral distance. Boorowa is about 125km north of Eugowra and 45km to the northwest of Oolong. The vertical red line shows the epicentral distance where the imputed ground shaking equals 0.1g, yet no damage was reported (photo of un-reinforced masonry in a Boorowa cafe below).*

**Photo** *One might classify this wall as vulnerable masonry at a business in Boorowa NSW, about 20k SE of the epicentre where the horizontal pga may well have exceeded 0.1g briefly*

## 'Freight train' earthquake triggers precautionary checks at regional NSW dams

by Melinda Hayter

https://www.abc.net.au/

Water NSW carried out precautionary checks of Wyangala and Burrinjuck dams to check for any unusual seepage. (ABC News: Jake Sturmer)

**Photo** *Burrinjuck Dam*

Richard Apps, who lives in Young, told the ABC Riverina breakfast program he initially thought the earthquake was a large truck driving by his home. "I hear this massive, really deep rumbling noise and thought 'gee, he must be going a bit quick', and I stuck my head out to see if I could see him drive past, and the next minute the whole family flies out of the house," he said. "The whole barbecue area was shaking and it was like someone was just wobbling the roof, like a bomb had gone off."

Water NSW spokesman Tony Webber said Burrinjuck Dam west of Yass, Wyangala Dam east of Cowra and Carcoar Dam were in the vicinity of where the quake struck. He said the storages were built to withstand seismic activity, and last night's earthquake was "well below" the threshold for concern.

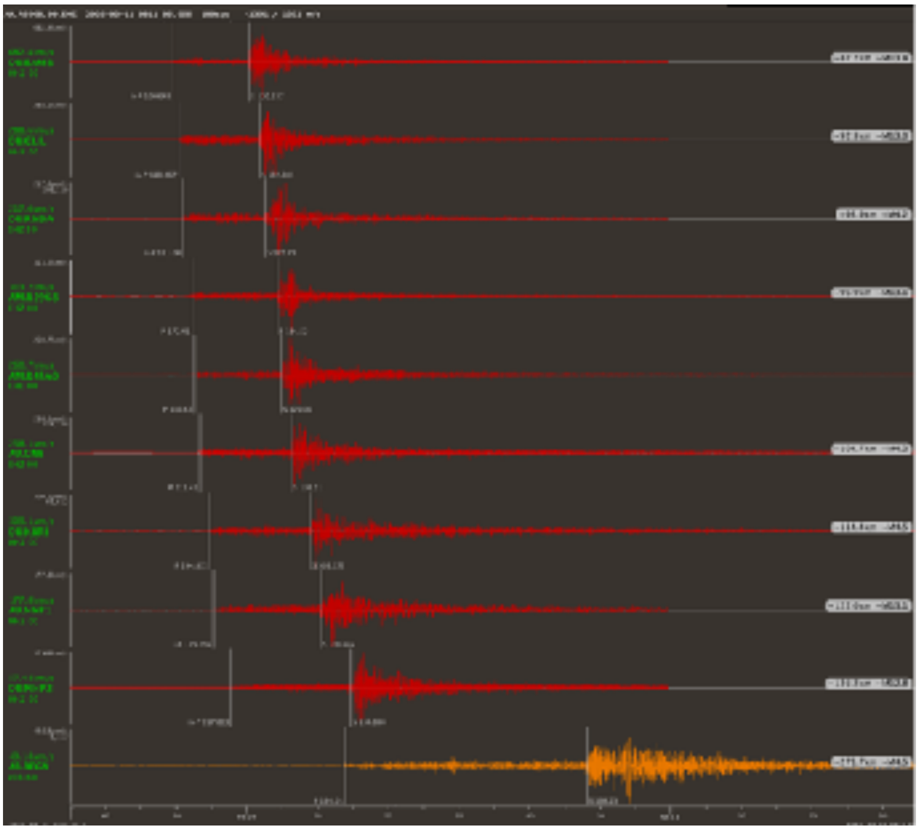


**Figure 8** *Seismograms recorded on SAA network stations in and around the ACT.*

But Mr Webber said crews would inspect the Wyangala and Burrinjuck dams as a precaution.

"As far as dam operations go, this is probably the biggest [earthquake] in the Central West, but we've had some comparable ones in the Hunter in the last few years," he said. "At this stage, you'd be looking for any increase in the seepage. All dams seep a little water and are designed to do so, but we certainly haven't seen it in this circumstance. "We've also invested in some very sensitive equipment within the dam walls themselves that [doesn't] detect movement, but detects changes in pressure in the wall." Mr Webber said the inspections were routine following an earthquake, and site visits overnight had not raised any concerns.

Rye Park resident Roger Kershaw told the ABC Central West breakfast program he had experienced earthquakes before, but none as significant as the one last night. "I was sitting on the back verandah minding my business, having a cold drink, and talking to a mate at Wee Jasper and within 10 seconds he said, 'I can feel it too' and he timed it, and it went for 35 seconds," he said. "It had the photos on the wall of the back verandah really rattling, but nothing fell down or got dislodged that I'm aware of."

Fellow ABC Central West listener Margaret Charles, who lives on a property just to the north of Goulburn, said she heard the earthquake before she felt it. "It was like a freight train coming through the house. You could hear it coming, then it hit us, and you could hear it going away again. Now our front door won't open because it's just moved slightly, so we've got to fix that."

There have been no reports of injuries or damage as a result of the quake.

The Canberra Times reported that it was the biggest earthquake in the region in almost 50 years.

The Canberra Times' Megan Doherty March 15 2026 wrote:

I'm glad I wasn't the only person not to feel the recent earthquake near Canberra. Retired seismologist and geologist, Dr Marion Leiba, an expert on earthquakes in Canberra, also felt nothing as she walked her greyhound in Kambah. Her daughter, Nadine, at home, also in Kambah, did feel it and quickly rang her mum.

"I was sitting on the couch with my cat watching the news and it felt like someone had suddenly pushed the couch forward," Nadine said.

After getting the call from Nadine, Dr Leiba, now 80, hurried home to check her own seismograph. Sure enough, there was a huge spike. "I checked the seismograph and went,'Wow'," Dr Leiba said.

Plenty of other people did feel the rock and roll of the magnitude 4.4 earthquake, which happened near Boorowa, north-west of Canberra at 7.09pm on Wednesday, March 11.

**Comment Editor**. "Dams are designed to withstand seismic activity well in excess of that experienced last [Wednesday]," a Water NSW spokesperson said (Parkes Champion-Post https://www.parkeschampionpost.com.au/news/parkes-feels-impact-of-boorowa-earthquake-ijlmb00h). We don't doubt the sincerity of the Water NSW spokesperson but:

1. Wyangala Dam construction commenced in 1928 and was completed in 1935. Wyangala Dam is the second oldest dam built for irrigation in New South Wales.The Dam is located approximately 50km from the epicentre of the recent earthquake NE of Boorowa. The current earth and rock wall was constructed between 1961 and 1971 due to fears that the original dam wall was beginning to lift away from its base, and as a result, would not be able to withstand a major flood (Ed. let alone a strong earthquake). A $43M upgrade of facilities commenced in 2009 and was completed in 2016 to raise and lock the spillway radial gates; raise the spillway chute wall; and raise the parapet wall crest. No mention of strengthening to withstand earthquakes. It would be interesting to hear from Water NSW just how Wyangala Dam was built to withstand earthquakes, such design well ahead of the introduction of the first earthquake code in Australia in 1979, Standards Australia's (AS1170.4-1979). They might also comment on whether the response of the dam wall to such shaking should actually be measured.

2. Engineers don't design for seepage, they cope with seepage through, around or under a dam and attempt to minimise it. They also diligently monitor the leakage, which is strange, as they seem to be so reluctant to monitor dam response in an earthquake. Even in Australia all dams get shaken sometime during their lifetime.

It was the biggest earthquake to hit the Canberra region in almost 50 years. Geoscience Australia seismologist Hugh Glanville said the last earthquake of a higher magnitude in the region was a 4.8 magnitude quake in 1977.

"That did cause some damage to the local area, but that's a reasonably larger earthquake than the magnitude 4.4 that we had on Wednesday night," Mr Glanville said.

Mr Glanville said the latest earthquake was felt as far south as Albury and Jindabyne and as far north as Dubbo and Newcastle. It was "reasonably large" but not "unusually large" for the local area.

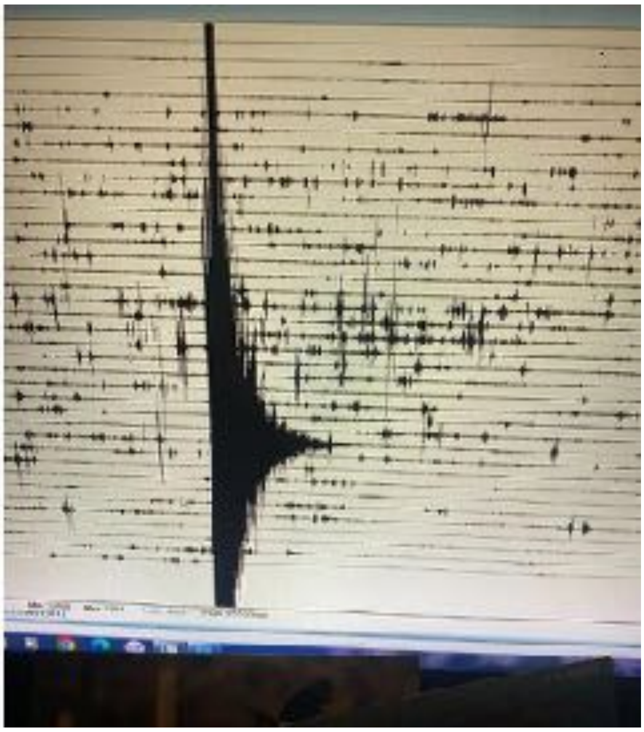
"We have had quite a few earthquakes around this size over the past 100 years in the region," he said.

Mr Glanville said an average of 17 earthquakes a year had been recorded within 100km of the one that struck on Wednesday night. That's 348 earthquakes in the last 20 years.

No earthquakes above magnitude 4 have been recorded in Canberra itself. The largest in the Geoscience records for Canberra was a magnitude 3.

"Canberra does however have a similar seismic hazard as the surrounding areas of NSW, so earthquakes, and earthquake damage, have a similar likelihood of occurrence in Canberra as the surrounding region."

Dr Leiba wrote the document *Earthquakes in the Canberra Region* for Geoscience Australia in 2007. She keeps her seismograph at home to keep her hand in the profession (Ed. with help and encouragement from SAA's David Love). Once a geologist, always a geologist," she said.



**Photos** *Dr Marion Leiba at work in 2001 and, right, the reading from her seismograph of the recent Boorowa earthquake. Pictures by Melissa Stiles, supplied.*

**Editor** In 1977 Boorowa NSW was hit by two earthquakes of magnitude 4.5 and 5.0 on 30 June at 10:48pm and 5 July at 6:05am. The 2nd and larger event was felt over a similar area to that of the 2026 earthquake.

The ANU Research School of Earth Sciences organised a rapid deployment kit (RDK) of nodal seismometers from the ANSIR pool of instruments the following day. Robert Pickle, Sima Mousavi, Juan-Santiago Velasquez, Jack Dent and Meghan Miller spent a beautiful day Thursday 12 March installing 22 nodes to capture aftershocks from the earthquake.

Stay tuned for updates on the data and analyses that will be shared on https://auspass.edu.au in about a month.

https://lnkd.in/eg_JqhX3

AuScope hashtag #NCRISimpact

The quarter was very quiet in **South Australia**, 4 earthquakes above magnitude 3 according to SAA. The largest was ML3.7, its epicentre in the Flinders Ranges .

In **Queensland and Tasmania** there were no earthquakes of M3 or more.

Unusually, the **Northern Territory** had just one earthquake of M3 or more, at Tennant Ck.

Ten small earthquakes were located by GA in **WA**.

In the Southeast of the continent there were six of magnitude 3 or more including the Boorowa earthquake. At the time of this Newsletter's publication there had only been 2 very small aftershocks recorded on the closest stations.

## ACT/NSW border earthquake

On 31 March at 7:40am AEDT, a magnitude 1.0 earthquake occurred west of Corin Dam in the ACT and 5km from Peter Smith's KBRI station in NSW. 10km deep, it was recorded clearly on SAA's ACT network and from Bega to Dalton.

## Gnowangerup WA swarm

David Love

A swarm of small events began about 12km NE of Gnowangerup WA on Saturday 14th February this year. Vic Dent quickly responded, going down on the Tuesday bus to install two instruments. GSWA followed soon after with four instruments. Both Vic and GWSA had multiple trips to the area to move and fix equipment.

The largest event was magnitude 3.8 with a few others being over magnitude 3.0. GA has reported more than 150 events over magnitude 2 so far, and 40 of these have felt reports.

Fifteen events on 5th March were located. Most of these were under magnitude 2. Standard deviation of residuals averaged about 0.25 sec, 1σ horizontal uncertainties typically were 70m, and 160m in depth. Figure 9 shows the location of the events, coloured by depth, and the closest recording sites. Depths are from 500 to 1500m, deepest to the NE and shallowest to the SW.

Assuming that all the events were rupturing in a similar manner, a combined focal mechanism was produced, using only impulsive arrivals. This is shown in figure 10. It appears that one station has the wrong polarity, producing the red dots on the right of the diagram. This has yet to be properly verified. Apart from this, other arrivals fit the mechanism reasonably well. The darker dotted line is the preferred plane, striking 145° and dipping 45° to the NE. This is in reasonable agreement with the mapped depths in figure 9.

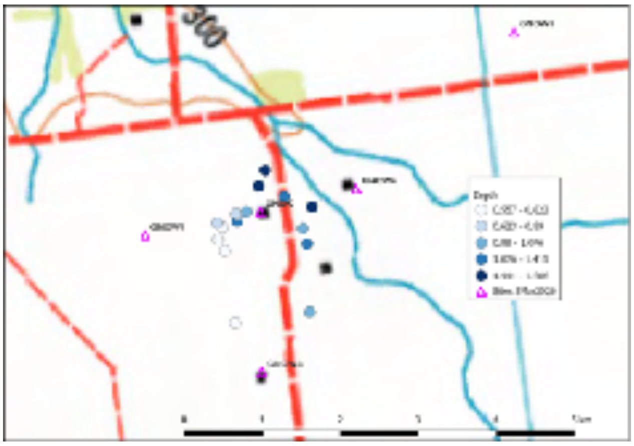


**Figure 9** Epicentres and temporary seismographs near Gnowangerup WA

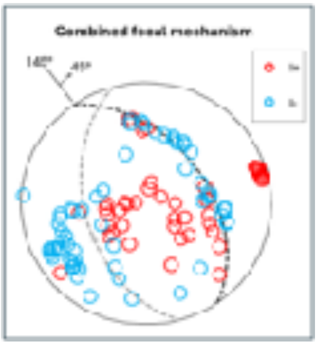



**Figure 10** Combined focal mechanism of swarm events near Gnowangerup WA.

## More T Phases from New Zealand

David Love

In January and February this year we recorded T phases from two earthquakes south of New Zealand. The first one was recorded by stations in Victoria, ACT and NSW. This included Peismos KBRI, CLIL, NNP1 and PFLO in the ACT network. Waveforms (1-20Hz filter) are shown in the figure. The depth of this one is listed as 33km by Geonet and 18.9km by USGS. Given the size of the T phase, it is likely that it is considerably shallower than these estimates.

| | Depth | Depth | Magnitude | Magnitude |
|---|---|---|---|---|
| Date Time | Geonet | USGS | Geonet | USGS |
| 2026-01-18 16:45 | 33 | 19 | 5.7 | 5.3 mww |
| 2026-02-02 08:15 | 5 | 10 | 5.5 | 5.3 mww |

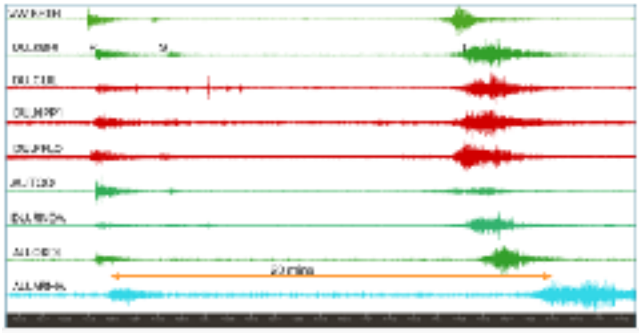


**Figure 11** T-phases recorded across southeastern Australia and the SAA network in the ACT. P and S wave arrivals are marked on the KBRI seismogram (Koorabri NSW operated by Peter Smith) and can be tracked across the network.

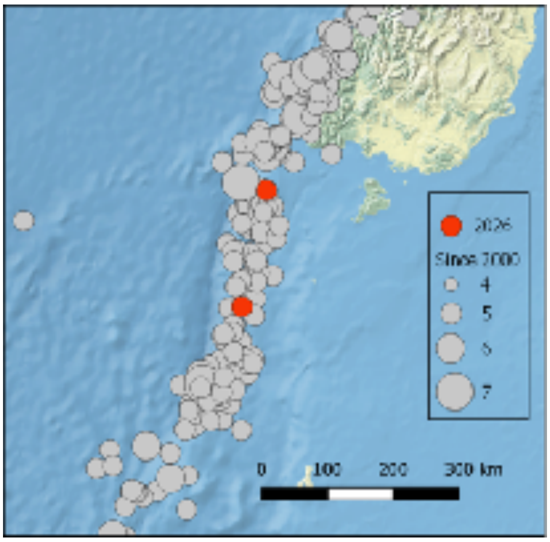



**Figure 12** Earthquakes south of New Zealand that generated the recorded T-phases (red dots)..

## In the hard-to-believe basket

from The Mercury, Hobart (March 16, 2026).

Missing deep-sea instrument found on beach after six-year journey from ocean floor

A chance discovery by a kayaker has solved the mystery of a missing earthquake detector that disappeared into ocean currents in 2020.

**Photo** Professor Mike Coffin from IMAS (previously at BMR Canberra) with the recovered scientific instrument lost in 2020 near Macquarie Island and recently found at Port Davey, on the west coast of Tasmania.

Picture: Nikki Davis-Jones

## Core phase interference - Cuba earthquake recorded in Australia

SAA member Clive Collins wrote to the Editor about an unusual recording across the ACT network of Peismos and an Echo in an urban environment: *I thought it was impressive that the local Peismo network recorded a magnitude 5.4 earthquake in Cuba. That's 14,900 km as the crow flies, though the arrivals might have cheated and only travelled 12,700 km through the core.*

**Figure 13** *Cuban earthquake epicentre location, 08/02/2026, 12:00:09 UTC, Magnitude 5.4Mw, focal depth 10km (assigned).*

The signal on more sensitive SA stations was even more dramatic, despite them being equidistant from Canberra stations.

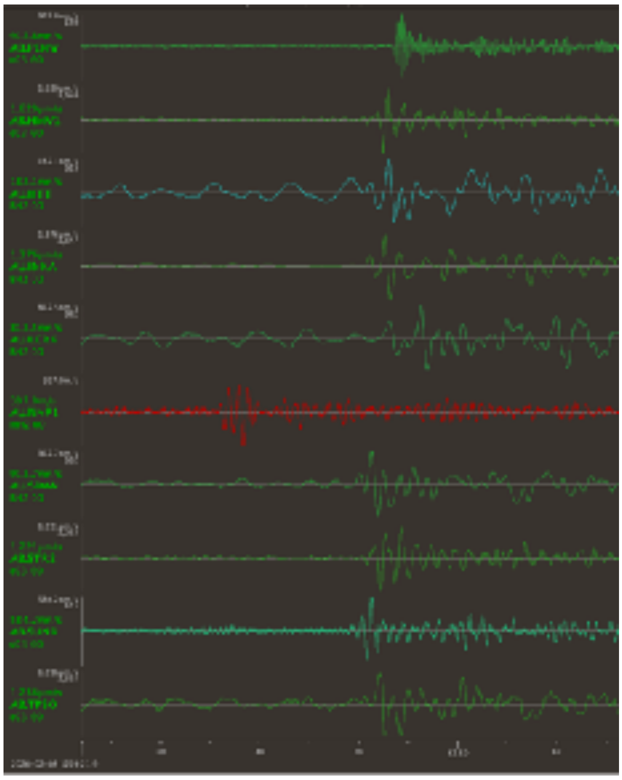


**Figure 14** *Seismograms (unfiltered) on selected SA stations (green and blue) and Peismo with Willmore Mk3A at NNP1 ACT (red).*

It seems the Earth's core has focussed the seismic waves from Cuba at our distance on the other side of planet Earth.

## Calibrating the accuracy of event locations in Queensland

by Mike Turnbull

I daily download data from available Queensland and other Australian seismic monitoring stations to identify and locate Queensland earthquakes. An important part of doing this is to discriminate between extraction industry blasts, natural earthquakes and mining related events. For the past several years I have requested and obtain blasting notifications from a number of Queensland mining operations, including the Commodore Mine,.

Periodically, I use the downloaded seismic data to do locations on mine blasts to confirm that the location methods I am using are reliable and accurate, and to assess the degree of precision errors resulting from my methodology. This cross-checking is important to maintain credibility of my locations, and to help me refine the methodology.

I located an ML 1.7 Commodore Mine blast conducted on Friday 2026-01-09 at 1100 AEST, as shown on the map. This demonstrates that my location method, using Gary Gibson's eqLocl program, designed back in the 1980s for the Classic Apple Macintosh computers, running in a Windows emulator (BasiliskII), is accurate to within 6 to 10 km using station records from up to 300 km away.

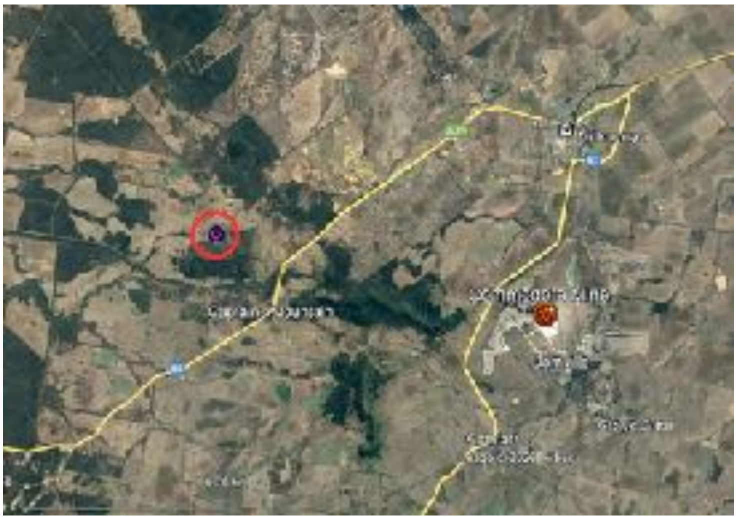


**Figure 15** *Mine blast location red blob and computed location red circle.*

**Peismo News** In the ACT the polarity of the NNP2 seismograph has been reversed (corrected). The first 3-component Peismo, designed and built by John Millard using ChatGPT will soon be on test in Canberra before being reinstalled at BEGA. There are now 4 Peismos in South Australia with the recent installation by David Love at PENW.

## 16th General Assembly Asian Seismological Commission (ASC) 2026

Under the banner "Intelligent Seismology, A Resilient Future," the Asian Seismological Commission (ASC) will hold its 16th General Assembly in Tashkent, Uzbekistan, from 25 to 30 April 2026.

The Assembly is set to be a defining forum for exploring how artificial intelligence and advanced computational methods are transforming seismology. The scientific program will highlight cutting-edge research in AI-powered earthquake forecasting, real-time hazard assessment, seismic data analysis, and risk mitigation strategies, aiming to build more resilient communities worldwide.

## The Seismological Association of Australia Inc.

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Membership of the SAA is open to anyone interested in earthquakes and applies for the calendar year (January through to December)

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Membership fees: Full member $50/yr

Hosted by the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan, the Assembly will also commemorate the Institute's 60th anniversary, reflecting on a legacy of seismic research.

## Changes at UTT and PENW stations

David Love

Station UTT on the hill's face NE of Adelaide used to transmit about 14km to Blair Lade's house via Freewave radio. With tree growth and wet weather, this had become unreliable. In October last year Blair and David converted the station to mobile phone using one of the spare Dualmax modems. The old rusted 4m aerial mast, long yagi and heavy coax were replaced by a tiny, dainty aerial on the cabinet. The station has performed well since, but began to have noise that appeared to be associated with solar charging. Blair and David recently visited and the old solar regulator was replaced by a new Victron model (arrow, photo 2). This will enable an easy change to a Lithium battery in the future. This appears to have solved most of the previous noise problem. While on site, a calibration was performed. This did not work as expected, so it was decided to uncover the borehole. While digging (with a screw driver) to clear the edges of the round paver a few bull ants appeared. When Blair lifted the paver it revealed an ant's nest. We brushed these away before undoing the bolts on the borehole cover (photo 1). A quick pull on the seismometer (20m down the hole) showed that it was still working. We are considering whether this station might be converted to a Peismo in the future, and retiring an old EchoPro.



Recently Jack Pappin moved from Skymuster satellite to Starlink when he changed his service provider. Unfortunately his seismograph (PENW – Penwortham, SA) stopped sending. Markus Wiedemann set up a test to confirm the problem. It turns out that the FTP used by the EchoPro cannot send over Starlink. So it was decided to swap the EchoPro for a Peismo, which uses SFTP. John Millard set up the Peismo, and gave David another lesson on changing Wifi services. David Love travelled to Penwortham on 19 March to do the conversion. The seismometer pit had accumulated a small puddle, despite the use of a large styrofoam plug. Jack is planning some earthworks to alleviate the problem. Photo 3 shows the seismometer pit and styrofoam plug. Photo 4 shows the new Peismo snuggled away in a corner of Jack's shed.



I learned that even with a "pure horizontal" motion of the sea floor along a fault line, if perchance the ocean floor topography is not flat but has significant topographic relief, valleys and peaks, even with a "pure horizontal" motion, these peaks and troughs can when moving horizontally past one another result in significant volumes of water being displaced.

## Thick Base" modification to VolksMeter

Designed in 2005 by Prof. Randall Peters, Larry Cochrane and Les Lazar the VolksMeter is a low cost pendulous digital seismometer and tiltmeter. It was manufactured in December 2025 by Blair Lade, Chairman, Seismological Association of Australia Inc.

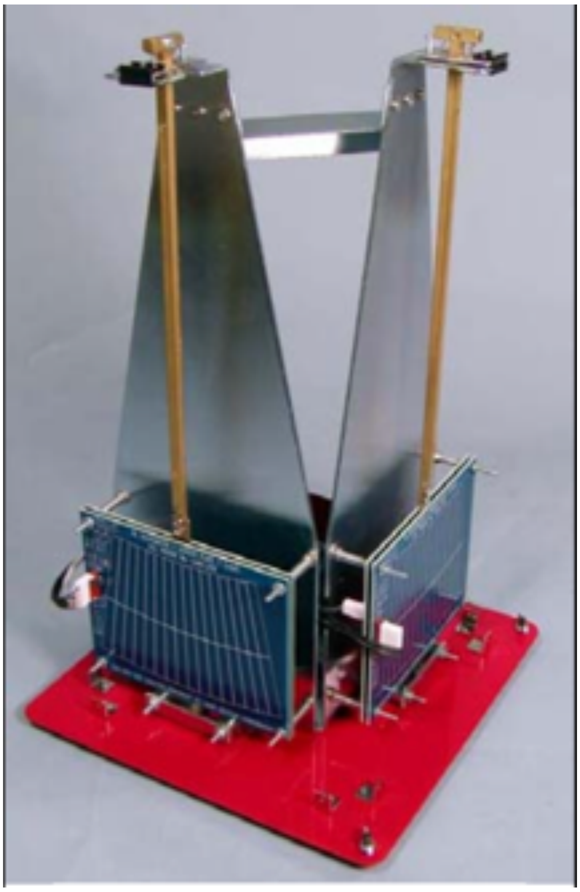

**Figure 16** VolksMeter with cover removed - showing general layout.

Two VolksMeters have been used at various times by the Seismological Association of Australia, on the seismic pier of The Peters Seismological Observatory (TPSO) located near Victor Harbor, South Australia, in the study of Earth Tides.

See Figure 18, which details what may well be world first Earth Tide research results that split the gravitational effect of the Sun and the gravitational effect of the Moon on the Earth's crust, using VolksMeter data from TPSO.

Earth Tides are the daily bulging and flexing of the solid Earth's crust caused by the gravitational pull of the Moon and the Sun. These forces stretch and compress the Earth's solid crust, creating measurable variations in its shape. Including the daily changing of the tilt of the crust, typically by some 70 nRad.

The VolksMeter, (and the Lipmann High Resolution Tiltmeter also located on the TPSO seismic pier), both have a theoretical tilt angle resolution of one nanoRadian (nRad).

An angle of one nRad is a vanishingly small angle, the thickness of a human hair at 100 kilometres away subtends an angle of about one nRad.

And any instrument sensitive enough and set up to consistently/accurately measure the minute angles of nRad's tilt over a long period of time, is faced with the real world reality that at the nRad level of measuring angles, anything and everything moves.

Even solid reinforced concrete floors act like one big slab of squishy marshmellow. A VolksMeter set up on a thick solid steel reinforced concrete floor, will record a significant change in tilt angle, if someone walks/stands on the concrete floor even though that person is located many metres away from the VolksMeter.

Even the very stable temperature inside the seismic vault at TPSO, varying no more than +/-0.75 Deg C. over the year, even this very small temperature variation over the year affects the accurate recording of nRad tilt. Causing the thin base plate of the VolksMeter to expand/contract, warp and flex ever so little, but enough to cause errors ("jumps") in the tilt record.

**Figure 17** *Showing the very thin base plate and coarse levelling screws*

Just how thin the base plate of the VolksMeter is, can be seen in Figure 17 above. What is not so obvious, is the three coarse-threaded thin levelling screws (32 turns per inch) that are loosely fitted/threaded into the thin base plate, giving what is at best, an unreliable wobbly instrument base support.

That is flexing/bending/warping under even very small temperature changes in the seismic vault, causing the loose coarse-threaded thin levelling screws to every now and then suddenly reposition/ move, giving a sudden "jump" in the tilt record.

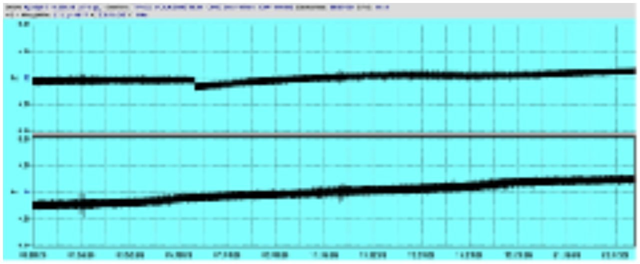

**Figure 18** *24 hour unfiltered VolksMeter 10 SPS trace of the 20thApril 2015 - TPSO*

Figure 18 above shows a "jump" in the E/W trace at about 06:00 hours UTC, being some 1100 counts or a sudden change in tilt angle of some 35 nRad.

The "Jump" is visually more easily seen, in the E/W "One Minute Average Count" chart of the same day, shown below.

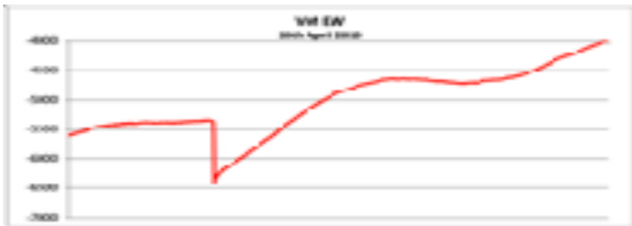

**Figure 19** *24 hour VolksMeter E/W trace of the 20th April 2015 - TPSO. "One Minute Average Count"*

It is assumed that temperature variations (no matter how small a variation within the seismic vault) caused the minute warping/twisting/expansion/ contraction of the thin base plate and/or movement of a levelling screw caused the "jump".

In order to improve the mechanical stability of the base of the VolksMeter, Blair replaced the thin metal plate and coarse-threaded loose thin levelling screws of VolksMeter "A" S/N 156, with a 20 mm thick aluminium base fitted with three micrometers for the levelling screws. Each micrometer leg rests on/in a circular small depression in the centre of a round metal disk, with each round disk supported on 3 pins. (See Figures 20 & 21).

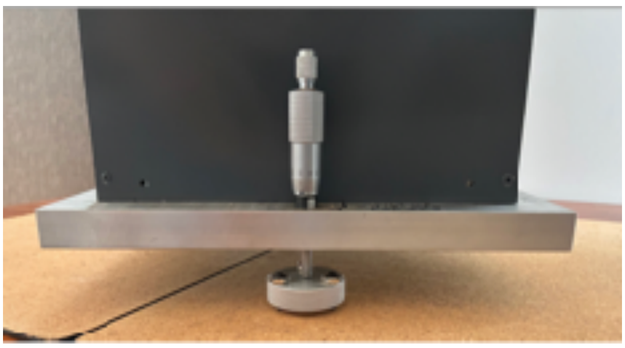

**Figure 20** *VolksMeter "A", with thick base fitted by Blair*

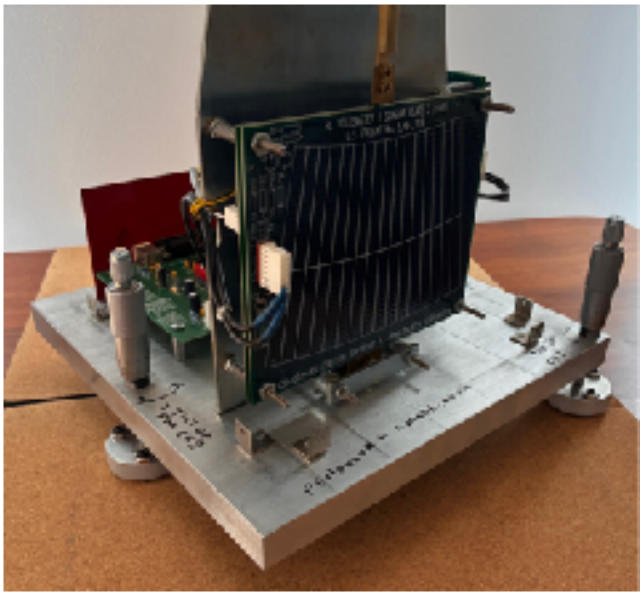

**Figure 22** *Showing handwritten notations*.

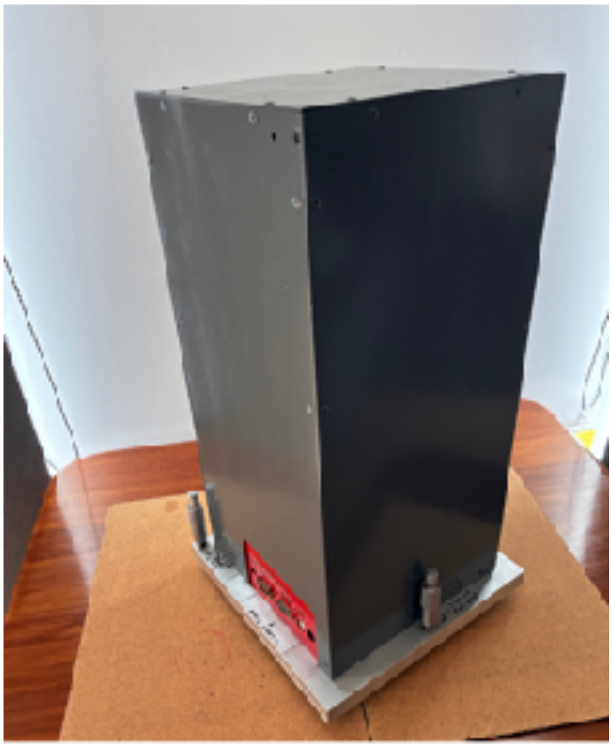

**Figure 21** *Showing 20 mm thick aluminium base. Three micrometer levelling screws each seated on a circular pad each pad with three pin support*.

The thick base with the three micrometer levelling screws, has already provided a distinct advantage in the ease and speed of setting up of the instrument.

The firmer base, with fine-threaded micrometers, has greatly reduced the time required to set-up the instrument (on a test bench).

Even so, even when in "coarse mode" for setting up and using 16 bits, the tiniest turn possible on the micrometer, will send the counts jumping by several hundred. In "fine mode", using 24 bit resolution, even the tiniest tiniest possible rotation of the micrometer will cause the counts to jump by many 10's of thousands of counts. Such is the sensitivity of the Volksmeter to tilt.

In addition having hand written notation on the base plate showing which way to rotate the micrometer to increase counts on a particular channel, which way the pendulum swings to increase counts on that channel, and, which way to face the instrument to North, so as not to have to invert any channel, also facilitates a faster set up time.

**Figure 23** *Showing replacement aluminium cover fabricated by Blair.*

Blair has also fashioned a replacement cover for the VolksMeter, made of aluminium, so that its removed from the instrument whilst in the seismic vault will not affect the nearby magnetometer.

Now the expectation is that once re-installed onto the seismic vault of TPSO, VolksMeter "A" with a "thick base" will again record Earth Tides but this time with greater fidelity.

**World first achievement in Earth Tide research**.

That is not to say, the standard "thin plate" VolksMeter on the seismic pier of TPSO has not already been a part of what could be world first earth tide research. As reported in the 6th March 2018 paper,

**Order out of Tidal Force Complexity**

Taking 169 days of continuous VolksMeter tilt data from the seismic pier of TPSO and using units of power (Watts/kg FFT-pt) which units strictly comply with S.I. nomenclature and using Mathematica FFT, Prof. Randall Peters showed what he claimed was a world first, the splitting of the 12.0 hour Solar earth tide from the usually observed 12.4 hour Lunar earth tide.

"Past experiments are evidently ones in which there have been constraints ... in which separation of the 12.4 of the Moon and the 12.0 of the Sun was not readily discernible, due to insufficient spectral resolution."

"What we are reporting, starting with Figure 1—is a solid first-piece of evidence for our conclusion that the Earth does not exist in the form of a geoid that is of largely static shape, in the form of an oblate spheroid -- that bulges nicely in the manner of assumptions used by gravitational potential theory.

Conventional wisdom evidently believes that the line-width of a semi-diurnal tide component is always too 'broad' to allow visibility of the component that is known to exist from the Sun; which contributes with a period of 12.0 hrs. If it has actually been noted in the manner reported here, we cannot find online evidence of such an observation."

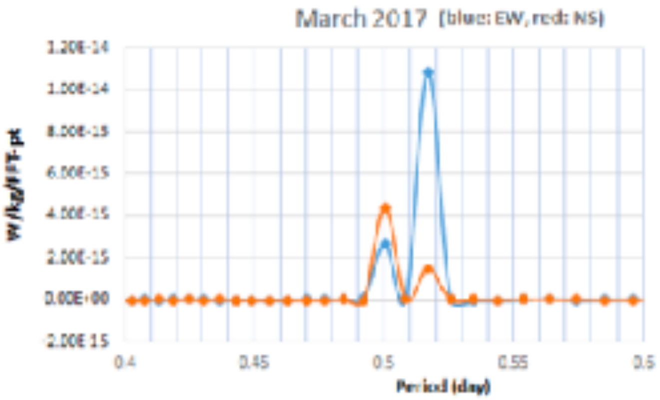


**Figure 24** *Being Figure No. 1 in "Order out of Tidal Force Complexity".*

Figure 24 above showing what is claimed to be the first time that the effect of the gravitational force of the Sun on Earth's crust at 12.0 hours (0.5 days) has been separated from the effect of the gravitational force of the Moon on Earth's crust at 12.4 hours (0.517 days).

Professor Peters stated, "These results are not unique to data collected from TPSO. Doublets have also been seen after a careful analysis of historic records that were graciously given to us by a scientist affiliated with a well-known, long-term European observatory. The details of that analysis remain to be published. Two different places on Earth-- seen with two different seismographic types—show clearly that the Earth is far too complex—to be understood on the basis of existing theoretical methods with which crustal tide estimates are performed."

That is, using high resolution tilt data from a very reputable long term seismic observatory in the Northern Hemisphere, being data from a very long period seismometer, the same splitting of the gravitational effect of the Moon and the Sun was also able to be shown on both E/W and on N/S channels.

**Conclusion**.

With such a track record of accomplishment already achieved by the "thin plate" VolksMeters on the seismic pier of TPSO, then can we expect anything less when we return the modified VolksMeter back onto the seismic pier of TPSO, now with a "thick base".

And can we now build upon the view expressed by Prof. Randall Peters, that,

"... the Earth is far too complex—to be understood on the basis of existing theoretical methods with which crustal tide estimates are performed."

Can we understand that the Earth may well have a crust that is more compliant, more adaptive and may well be reacting to the gravitational forces of the Moon and reacting to the gravitational forces of the Sun more in a granular manner than the nice smooth bulge predicted by current Earth Tide models.

And can we believe that further research into the daily changing pattern of the energy levels of whole of Earth eigenmodes may be worthwhile, hopefully shedding new light and new understanding on the geophysical mechanisms of our Globe.

We have the instruments, we have the seismic vault, but do we have the will?

Paul Hutchinson

[1] Michael Rivero. PRECISE TILTMETER AND INCLINOMETER BASED ON COMMERCIAL FORCE COMPENSATION WEIGH CELLS. http://www.researchgate.net/profile/Michel_Rivero/publication/270217245_Precise_tiltmeter_and_inclinometer_based_on_commercial_force_compensation_cells/links/54a313d10cf267bdb9042ea8.pdf

[2] Lippmann High Resolution Tilt Meter – resolution < 1 nRad. https://www.l-gm.de/en/en_tiltmeter.html

Volksmeter – resolution 3.01 counts per nanoRadian.

[3] Calibrating your VolksMeter. https://www.map.id.au/seismic/volksmeter_calibration.html

[4] Order out of Tidal Force Complexity. Peters & Hutchinson, Copyright 6 March 2018. Yet to be submitted to arXiv.

## Research Unveils Rare Deep Earthquake Activity

from https://www.miragenews.com/research-unveils-rare-deep-earthquake-activity-1614828/

Stanford University researchers have created the first-ever global map of rare mantle earthquakes, in the layer sandwiched between the thin crust and Earth's molten core. As reported in a study published Feb. 5 in Science by Wang and

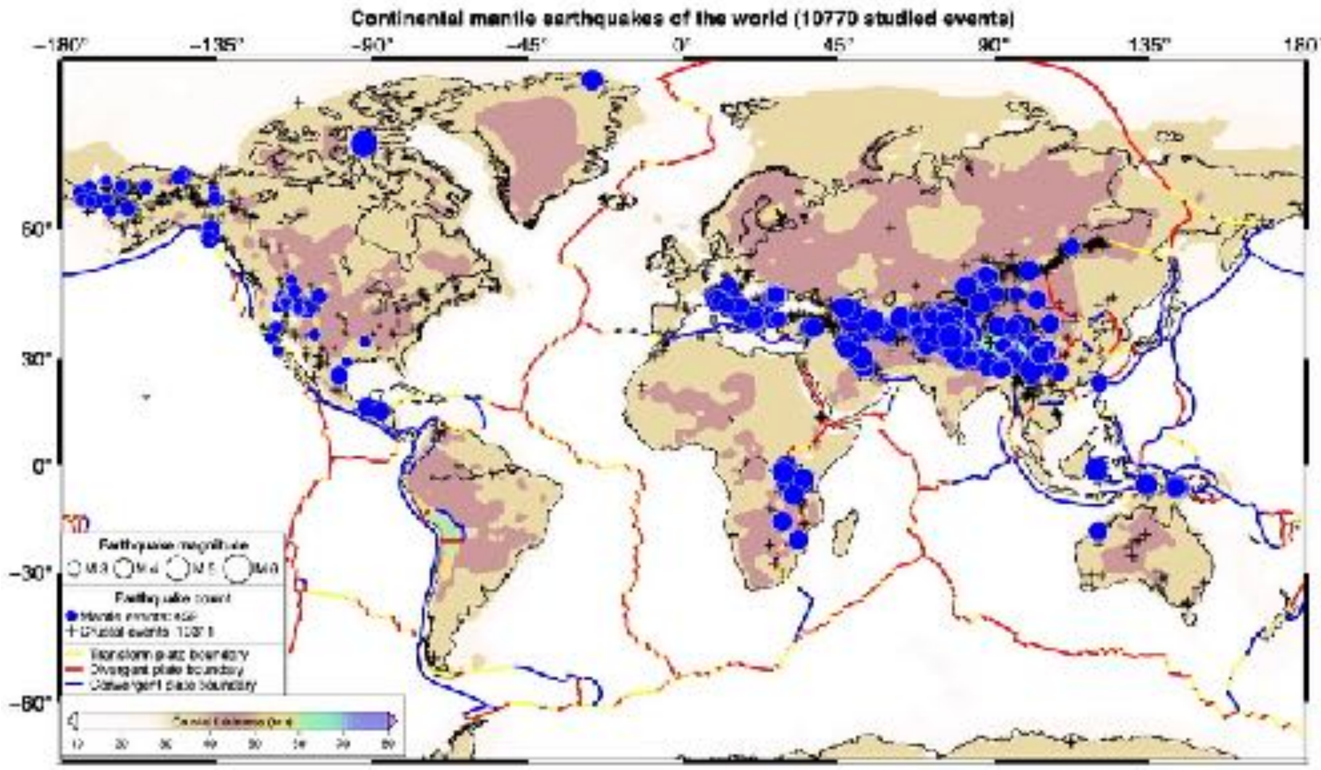


**Figure 25** Blue dots showing mantle earthquakes identified since 1990, just one of 459 of them under NW Australia.

Klemperer, continental mantle earthquakes occur worldwide but are clustered regionally, particularly in the Himalayas in southern Asia and the Bering Strait between Asia and North America, south of the Arctic Circle.

"Until this study, we haven't had a clear global perspective on how many continental mantle earthquakes are really happening and where," said lead study author Shiqi (Axel) Wang, a former PhD student in the lab of geophysics professor Simon Klemperer at the Stanford Doerr School of Sustainability . Continental mantle quakes are too deep to cause much shaking or danger at Earth's surface.

### Above and below the Moho

Unlike Earth's cold, brittle crust, the mantle is a warm, semisolid zone of dense rock about 3000 km thick that comprises the bulk of our planet's interior. The boundary between the crust and the mantle is known as the Mohorovičić discontinuity, or "Moho."

The origin of most continental earthquakes measure to depths of roughly 10 to 30 km, which is in the crust above the Moho. Noted exceptions are subduction zones, where denser oceanic plates dive under lighter crustal plates, sometimes unleashing quakes from hundreds of miles down. Yet sensor measurements have at times pointed to far deeper, sub-Moho hypocenters under continental landmasses, away from subduction zones, even 50 miles below the Moho.

Evidence of rare mantle earthquake over the last 10 years suggests that they occur  roughly 100 times less often than crustal quakes. To distinguish mantle earthquakes from crustal earthquakes, Wang and Klemperer developed a method for comparing two types of seismic waves called Sn or "lid" waves, a type of shear wave that travels across the top of the mantle known as the "lid," and Lg waves, which are high-frequency undulations that bounce around easily through the crust. The ratio of the waves' sizes determines their origins. "Our approach is a complete game-changer because now you can actually identify a mantle earthquake purely based on the waveforms of earthquakes," said Wang.

## Rarities galore

The researchers whittled an initial set of over 46,000 earthquakes down to 459 identified continental mantle earthquakes since 1990. The total number is conservative, the researchers said. A good deal more mantle quakes would likely be captured by expanding sensor networks, particularly in remote areas such as the Tibetan Plateau that ranges north from the dramatic uplift of the Himalayas.

Wang and Klemperer plan to delve more into the particulars of these rare events. Some appear to be aftershocks spawned by propagating seismic waves from crustal earthquakes. Others might burst forth from the heat-driven convection of the mantle itself as it recycles subducted slabs of Earth's crust. "Continental mantle earthquakes might be part of an inherently interconnected earthquake cycle, both from the crust and also the upper mantle," said Wang. "We want to understand how these layers of our world function as a whole system."

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## Comment by Editor

The Stanford University researchers found only one deep earthquake under Australia but in the last 40+ years Australian seismologists reported on earthquakes below the brittle upper crust at or near the Moho: in Southeast South Australia (Love, et al., 2004), Northwest Western Australia on 20 February, 1979 (McCue, 1996) and off the north coast of the NT (Michael-Leiba and McCue, 1993). It is interesting to speculate that crustal distortion caused by these large mantle earthquakes may help explain the why of shallow crustal intraplate earthquakes.

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Love. D., Gibson, G., and McCue, K. 2004 Anomalous Tectonism in SouthEast South Australia. AEES Conference Mount Gambier 5 - 7 November 2004, Paper 29.

McCue, K F and Michael-Leiba, M. O. 1993. Australia's deepest known earthquake, Seismology Research Letters, 64 (3-4), 201-206.

McCue, 1996. (Compiler) Atlas of Isoseismal Maps of Australian Earthquakes, Part 3. AGSO Record, 1995/44.


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## Obituary
## Raymond Arthur William Haddon
## (1936 – 2025)

from IASPEI Newsletter March 2026

Dr. Raymond Arthur William Haddon, born on 4 October 1936 in Palmerston North, New Zealand, passed away on 31 December 2025 in Taupo, New Zealand, after having lived for decades in other countries, notably Australia (1961-1981) and Canada (1982-1996). He also spent altogether two years in Norway (1973, 1975-77, 1997 and 2000).

Ray's academic career started with a B.E. in Aeronautical Engineering from the University of Auckland in 1961, followed by a B.Sc. in applied mathematics from the University of Sydney in 1963, and from the same university a M.Sc. in 1965 and a Ph.D. in 1971. He taught, in various positions, applied mathematics at the University of Sydney between 1961 and 1981. In 1982 he took up a position at the Earth Physics Branch, later merged into the Geophysics Division of the Geological Survey of Canada, until his retirement in 1996, when he moved back to New Zealand (Taupo). His two years in Norway were spent as a visiting scientist at NORSAR.

With Ray Haddon's passing the world has lost a great mathematical geophysicist and a great earth scientist. Ray was a highly principled, innovative and knowledgeable scientist.

Ray's main collaborator in Sydney was Prof. Keith Bullen, his advisor for his Ph.D., which was concerned with derivation of whole Earth models using free earth oscillation data. These Haddon-Bullen earth models, which involved joint interpretations/inversions of various types of seismic and gravity data, were well ahead of their time. Certain aspects of that work also led Ray to focus on detailed core structure, including doubts on the (then currently accepted) existence of transition layers surrounding the inner core. This was followed up by his (for the first time) proposal for the existence of small-scale heterogeneities in the vicinity of the core-mantle boundary, and he also proposed that seismic wave scattering caused by these heterogeneities was the probable mechanism responsible for the observations. These interpretations, some of which he published with ANU's John Cleary, were subsequently confirmed through independent studies.

Between 1973 and 1977 Ray had several visits to Norway in order to take advantage of the wealth of new data available from the new and large NORSAR array, and to work with scientists there, notably E. S. Husebye and D. W. King, the latter also visiting from Sydney. Inspired by the work by King, Haddon and Cleary using data from the Warramunga array in Australia, the much larger NORSAR array now made possible a more detailed analysis of precursors (to PP, PKIKP, and P'P'). This built on Ray's recent work on seismic wave scattering, applied here to the mantle-core boundary and to the upper mantle. A particularly interesting paper from this cooperation was a joint interpretation of P-wave time and amplitude anomalies in terms of lithospheric inhomogeneities, based again on the unique NORSAR data.

These publications were in turn supported by Ray's theoretical works within modelling of wave propagation in 3-D inhomogeneous media in both the lower and upper mantle, including extension of Born scattering theory to random solid media, development of the Kirchhoff integral method for inhomogeneous media, and development of applied 'thin-lens' (or 'phase screen' methods for modelling wave propagation in inhomogeneous media.

In support of subsequent forward modelling applications Ray also developed solutions for wave propagation in layered media, including developments to the theory of leaking modes, synthesised frequency-wavenumber methods of Abo-Zena, Bouchon, and Menke for accurate and efficient computation of 3-D Green's functions for complex layered crustal models for frequencies up to 30 Hz and distances up to several hundred kilometres. In short, the method provides complete synthetic seismograms for spatially extensive rupture sources and layered crustal models.

Following the 1988 M5.9 Saguenay earthquake Ray's focus turned to the interpretation of this and other crustal earthquakes. He developed the modelling theory, code and graphics and recognised the power of spectral ratios to remove path effects and therefore reveal the nature of the rupture source. Through iterative forward modelling Ray found that the Saguenay earthquake most likely was a high rupture velocity, asymmetric rupture with strong directivity and a partial (but typical) stress drop rather than a high-stress-drop, nearly-point source as was being modelled at the time. He applied his tools also to other eastern Canadian earthquakes and demonstrated that most were complex, having episodic and asymmetric ruptures that propagated at high rupture velocity, thereby casting doubt on the extrapolations to larger magnitudes within contemporary stochastic approaches to ground motion estimation.

More detailed information on Ray's scientific contributions is available from a web search, such as from Google Scholar. Of his many publications, 10 were printed in BSSA, 9 in PEPI, 8 in GJRaS/GJI, 4 in AGU journals, and 4 in Nature. It is noteworthy that besides his many papers with Prof. Bullen he also published one with Sir Harold Jeffreys, FRS.

Ray went for an early retirement from NRC in 1996, going back, together with his wife Jo (dec.), to the country where he grew up. In this he was attracted by New Zealand's wilderness, wildlife and hunting grounds, which were very important for him. Unfortunately, on one such tour from his home in Taupo in 2012, with his dogs, he suffered a stroke which affected him significantly to the end of his days. Ray Haddon is survived by his sons James and John, and he will be missed by many more, colleagues and friends alike.

by Hilmar Bungum and John Adams, with contributions from Alan Green (including the photo).