Seismological Association of Australia

SAA Newsletter

#1/2023

From the Editor Your committee has decided to continue with a newsletter for a while but hope that members will get used to checking the new website regularly for such information. We encourage members 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 editor.

We thank the founding editor Peter Gray for his outstanding contribution which we will not try to emulate with this publication.

Contribute articles to: mccue.kevin@gmail.com

Earthquakes worldwide so far this year – 2023

Those of us running seismographs always get a buzz when they see they have recorded a large distant earthquake but immediately wonder where it was, how big and how deep it was and what has been the impact in the epicentral region; damage, landslides, tsunami, life-loss. With experience you can often make a pretty good guess at all these unknowns.

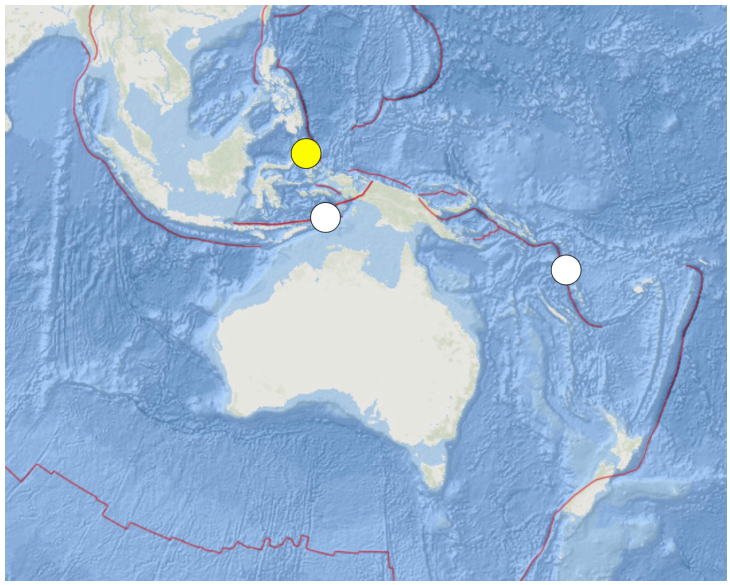


Figure Location of the World's three major earthquakes, M>6.9, so far in 2023, from the USGS.

Having a network such as the SAA one on the UniMelb website available makes the task a lot easier. In January this year already we have recorded 3 earthquakes of magnitude 7 or more, triple the number expected in any month. The first was in Vanuatu on 8 January, a shallow magnitude 7.0 earthquake. This was soon followed by a magnitude 7.6 earthquake at about 100km depth on 10 January beneath the Banda Sea Indonesia (see article below), the third a shallow earthquake also in Indonesia..

The deepest known onshore earthquake in Australia

by David Love

A magnitude 3.4 earthquake occurred on Eyre Peninsula on 5 Jan 2023 at 06:32UTC. The computed depth was about 44 km, the deepest reported for on-shore Australia.

The spread of available seismograms is quite good. The nearest station was Cleve, 38 km to the southwest. Using all seismographs (ANU, GA and SAA) resulted in a good azimuthal distribution with a maximum gap of 88°. The standard deviation of residuals was 0.32 sec, using 32 (of 33 possible) arrivals from 17 stations out to 450 km. The model used was SA1A which has the Moho at 38 km deep. P and S arrivals were quite clear with other conspicuous arrivals on closer stations.

Using stations only out to 200 km resulted in a depth of 43 km. Using these same arrivals (<200km) and changing to other models (WA2, VIC5A, DAL1A, SYD3A) gave depths ranging from 42 to 47 km.

The epicentre was in a hilly region of moderate activity north-east of Cleve. Past earthquakes in the region have included a ML(SA) 5.0 event on 2010-06-05. The mainshock gave a depth via the regional network of 22 km, with ISC depth phases suggesting 16 km. An aftershock survey for this event gave well constrained depths of 24 km. Other events nearby in recent years with reasonable coverage have been:

Date	Depth	ML(SA)
2018-04-30 1126	27	2.2
2018-07-01 0227	26	3.8
2018-11-21 1558	38	3.7
2018-12-28 1925	26	1.8

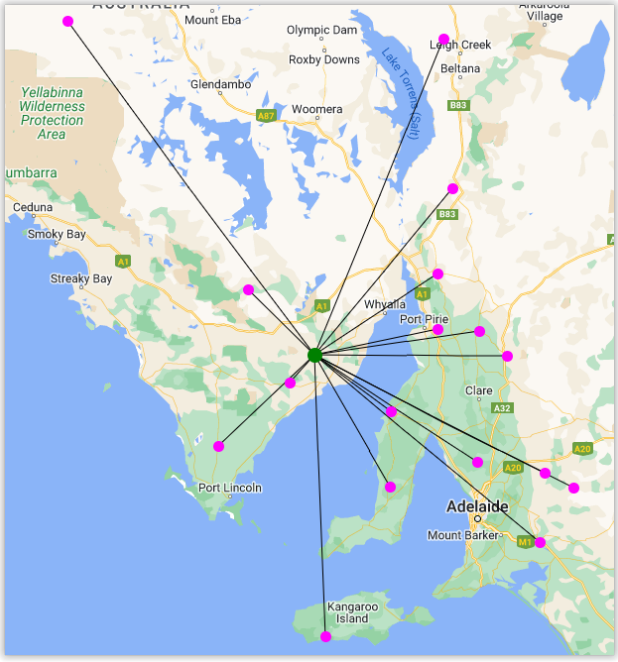


Figure 1 (left) Stations used in the location calculation, showing fair azimuthal distribution and an 88° gap.

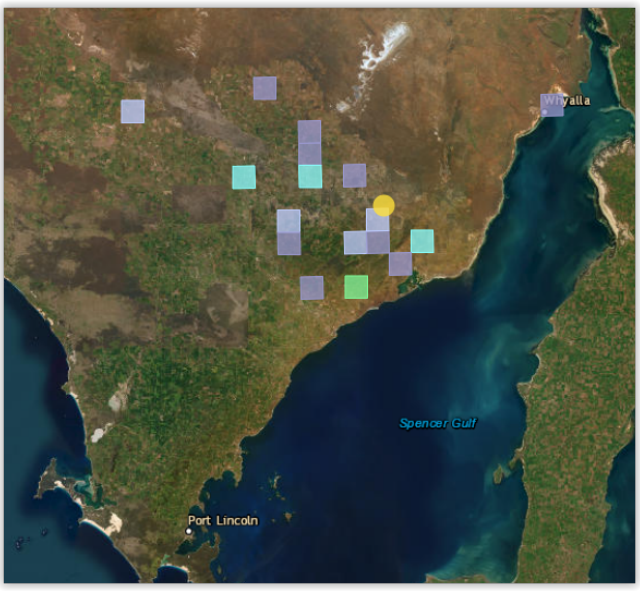


Figure 2 (right) Geoscience Australia received eighteen felt reports, fairly low intensity and widely scattered across the region. The epicentre is the yellow dot.

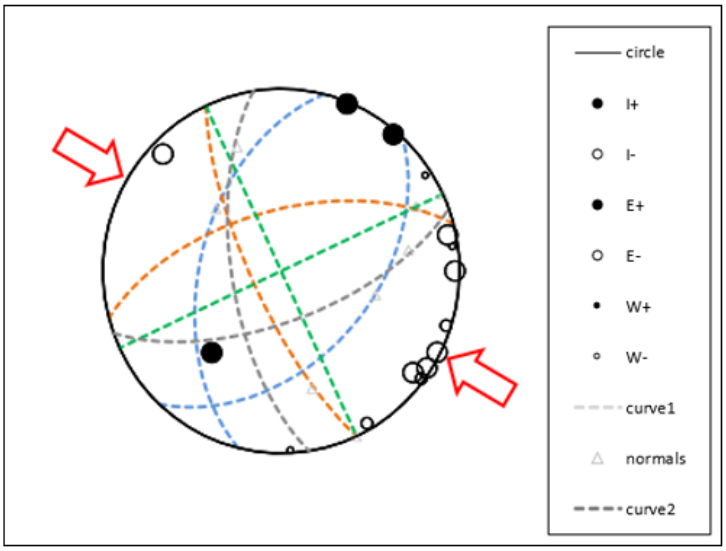


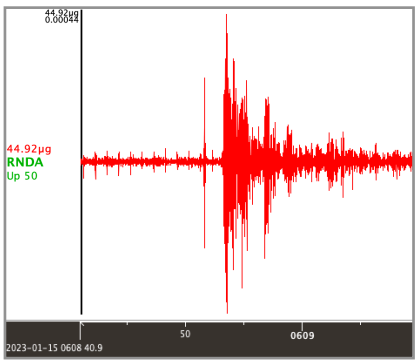
Figure 3 Focal mechanism derived from the P wave first motion direction, up (black circle) or down (open circle, (lower hemisphere) indicates NW-SE compression, but the two nodal planes, one of them the fault plane, are poorly constrained. Several possible options are shown representing a thrust (blue or grey) to a strike-slip (green) type of mechanism.

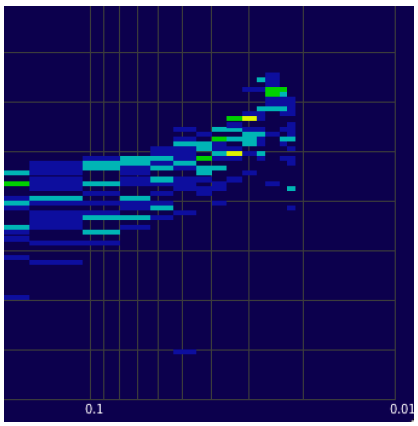
Ed. Was this earthquake really in the mantle or is the mantle deeper in the Gawler craton than thought?

Further reading

- Love, D., Dent, V., and Gibson, G. 2012. Earthquake depths in Australia. 34th International Geological Convention, 5-10 August 2012, Brisbane, Australia.
- McCue, K.F. & Michael-Leiba M.O., 1993. Australia's deepest known earthquake. Seismology Research Letters, 64 (3-4), 201-206.
- Michael-Leiba, M.O., Love, D., McCue, K.F., & Gibson, G., 1993. The Uluru (Ayers Rock), Australia earthquake of 28 May 1989. Bull. Seismological Society of America, 84, 1, 209-214.

What shakes the ground other than earthquakes?





Nuclear explosions, chemical explosions, aeroplane and rocket crashes, meteorites, kangaroos and even train crashes are recorded on sensitive seismographs. A near simultaneous lightning strike and thunder nearly knocked me off my feet while standing on our front porch on Sunday 15 January as a violent storm passed over Canberra. I noted the time and later checked the Kelunji Echo seismograph output. Yes it registered.

The accelerogram is shown opposite, the ground motion very small, the displacement negligible. The peak of the power spectrum in the Waves plot below is at about 40Hz as the filter started kicking in. I had expected a much larger induced emf in the charger, seismometer lead or seismometer coil but no.

I wonder if others have recorded something similar.

Kevin McCue

Darwin, Northern Territory, shaken by a magnitude 7.6 earthquake on 10 January 2023 at 3:17am ACST

after Thomas Morgan abc.net.au/news/nt-earthquake-tsunami-7-7-darwin/101839192

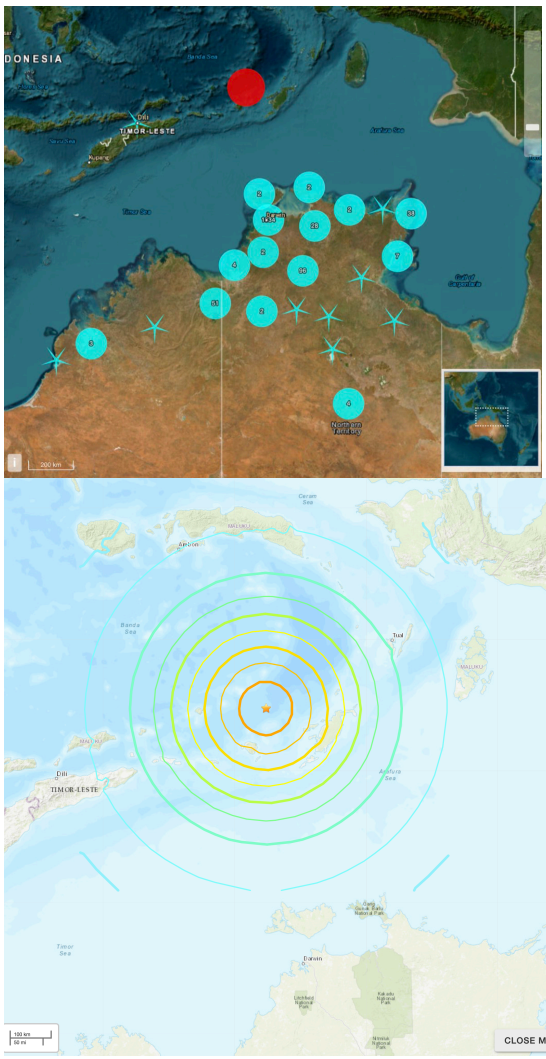


Figure 1 Location and felt reports from GA (top), and modelled intensities from the USGS (bottom).

Note: Hopefully the real data will inform the USGS model for future events.

At 3:17am ACST on Tuesday, the undersea earthquake hit less than 600 kilometres north of the Northern Territory capital. The Bureau of Meteorology (BOM) says there is no risk of a tsunami after Territorians were awoken by a magnitude 7.7 earthquake north of Darwin overnight. Residents across Darwin, Palmerston,

Figure 3 A house damaged in the 7.6-magnitude earthquake in the Tanimbar islands in Maluku on Jan. 10, 2022.

Katherine and Arnhem Land reported feeling tremors.

Note: Two school buildings and at least 15 homes were damaged in the Tanimbar islands, said Indonesia disaster agency officials, with one person injured. The photograph shows the very poor quality of the unreinforced masonry walls that collapsed.

The European Mediterranean Seismological Centre said the earthquake was a magnitude 7.7 and hit 97 kilometres beneath the Earth's surface.

Note: The USGS reported the depth at 105.1km, BMKG 131km and GA 67km. Very inconsistent!

More than 2,400 people had reported having felt the earthquake to Geoscience Australia by 5am ACST.

Immediately following the tremor, social media lit up with reports of being woken by shaking, many saying it was the strongest quake they had felt in the territory. One person from Weipa said they had felt shaking in Weipa, on Cape York in Queensland. Other media report: The impact was felt in Darwin and other parts of the Top End, including Katherine as far south as Tennant Creek and into the far southern Kimberley region.

A Darwin resident told the Nine network the quake was the worst he had felt in 40 years in the city and over two minutes it shook more and more, accompanied by a roaring sound. "The house started shaking then she really started shaking to the point you could hear the windows start to rattle and creak." He said his family rushed outside where the car was shaking in the driveway and the dogs were "going absolutely crazy".

The Canberra Times indicates that while no injuries or infrastructure damages were reported initially, many Darwinites had smaller items topple off shelves, and locals said they could not only feel but also hear the ground move and buildings grind. Felt across most parts of the Northern Territory, including Borroloola and Nhulunbuy, in Katherine the quake rattled doors and windows, and residents said floor boards, roof trusses and brick walls groaned, with tremors being felt for more than a minute. The Washington Post reported: Two school buildings and 15 houses were damaged in the Tanimbar islands, with one of the homes heavily damaged and three moderately damaged. Only one injured resident was reported.

"Local residents felt strong tremors for three to five seconds. There was panic when the quake shook so the residents left their houses," Abdul Muhari, spokesperson of the National Disaster Mitigation Agency, said in a statement, citing the local agency. The epicentre of the magnitude 7.6 temblor was in the Banda Sea, nearest the Tanimbar islands in Maluku province that have about 127,000 residents, according to 2021 data. Tremors were felt in several regions, including Papua and East Nusa Tenggara provinces, as well as in northern Australia.

BMKG warned about a potential tsunami initially, but then lifted the warning. They also reported some aftershocks to a magnitude of 5.5.

Note: Given the focal depth, the rupture would not have extended to the surface so no tsunami would have been expected.

A megathrust earthquake off Sumatra on Dec. 26, 2004, set off an Indian Ocean tsunami that killed more than 230,000 people locally and as far away as Sri Lanka, India and Thailand. That powerful 9.1 magnitude quake triggered 100-foot waves that hit the shore of Banda Aceh on Sumatra.

Note: Let this be a warning for Australian Emergency Management agencies of what the long subduction zone between Timor and Tanimbar is capable of for the northern and northwest coasts of Australia. This part of the plate boundary spawned a magnitude 8.5 earthquake in 1938, bigger will happen.

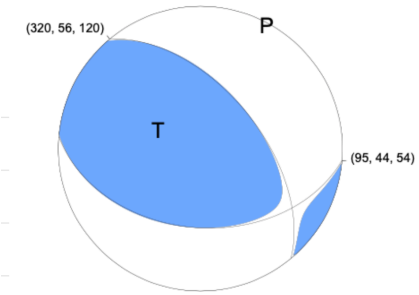


Figure 4 The focal mechanism from the USGS is a typical thrust mechanism with horizontal maximum stress P direction and vertical minimum stress T direction.

USGS Moment Tensor Solution

M 7.6 Pulau Pulau Tanimbar, Indonesia, 2023-01-09 at 17:47:35 UTC.
7.049°S 130.038°E, 105.1 km depth

Note: The direction of the principal stress P marked on the focal mechanism is very similar to the direction of movement of the

Australian Plate relative to the Pacific Plate.

USGS Tectonic Summary

The Australia-Pacific plate boundary is over 4000 km long on the northern margin, from the Sunda (Java) trench in the west to the Solomon Islands in the east. The western end of the Australia-Pacific plate boundary is perhaps the most complex portion of this boundary, extending 2000 km from Indonesia and the Banda Sea to eastern New Guinea. The boundary is dominantly convergent along an arc-continent collision segment spanning the width of New Guinea, but the regions near the edges of the impinging Australia continental margin also include relatively short segments of extensional, strike-slip and convergent deformation. The dominant convergence is accommodated by shortening and uplift across a 250-350 km-wide band of northern New Guinea, as well as by slow southward-verging subduction of the Pacific plate north of New Guinea at the New Guinea trench. Here, the Australia-Pacific plate relative velocity is approximately 110 mm/yr towards the northeast, leading to the 2-8 mm/yr uplift of the New Guinea Highlands.
Whereas the northern band of deformation is relatively diffuse east of the Indonesia-Papua New Guinea border, in western New Guinea there are at least two small (<100,000 km²) blocks of relatively undeformed lithosphere. The westernmost of these is the Birds Head Peninsula microplate in Indonesia's West Papua province, bounded on the south by the Seram trench. The Seram trench was originally interpreted as an extreme bend in the Sunda subduction zone, but is now thought to represent a southward-verging subduction zone between Birds Head and the Banda Sea.

The western portion of the northern Australia plate boundary extends approximately 4800 km from New Guinea to Sumatra and primarily separates Australia from the Eurasia plate, including the Sunda block. This portion is dominantly convergent and includes subduction at the Sunda (Java) trench, and a young arc-continent collision.

In the east, this boundary extends from the Kai Islands to Sumba along the Timor trough, offset from the Sunda trench by 250 km south of Sumba. Contrary to earlier tectonic models in which this trough was interpreted as a subduction feature continuous with the Sunda subduction zone, it is now thought to represent a subsiding deformational feature related to the collision of the Australia plate continental margin and the volcanic arc of the Eurasia plate, initiating in the last 5-8 Myr. Before collision began, the Sunda subduction zone extended eastward to at least the Kai Islands, evidenced by the presence of a northward-dipping zone of seismicity beneath Timor Leste. A more detailed examination of the seismic zone along it's eastern segment reveals a gap in intermediate depth seismicity under Timor and seismic mechanisms that indicate an eastward propagating tear in the descending slab as the negatively buoyant oceanic lithosphere detaches from positively buoyant continental lithosphere. On the surface, GPS measurements indicate that the region around Timor is currently no longer connected to the Eurasia plate, but instead is moving at nearly the same velocity as the Australia plate, another consequence of collision.

Large earthquakes in eastern Indonesia occur frequently but interplate megathrust events related to subduction are rare; this is likely due to the disconnection of the descending oceanic slab from the

continental margin. There have been 9 M7.5+ earthquakes recorded from the Kai Islands to Sumba since 1900. The largest was the great Banda Sea earthquake of 1938 (M8.5) an intermediate depth thrust faulting event that did not cause significant loss of life.

Note: What a shame there are no instrumented buildings in Darwin (see next article).

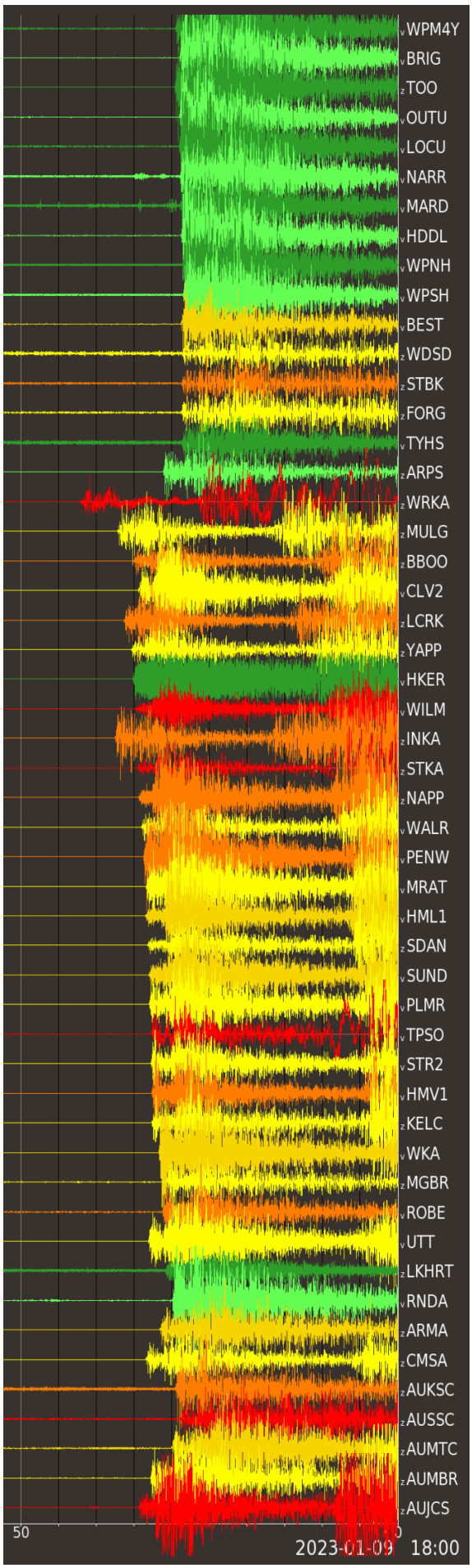


Figure 4 A beautiful 10 minute clipping from Gary Gibson's Melbourne University Server of the Tanimbar Island earthquake of 9 January at 17:47 UTC. The S phase is quite apparent on the closer instruments such as WRKA.

Table Intensities in Indonesia according to the BMKG.

Date/ Time	Location	M	D km	Felt reports
10/01 /2023 00:47 Local time	-7.251 30.18º	7.9	131	V Saumlaki III-IV Sorong III-IV Kaimana II-III Merauke II-III Nabire II-III Tanah Merah II-III Wamena II-III Bakunase II-III Kolhua II-III Sabu II-III Rote II-III Ende II-III Amarasi Selata II-III Kota Kupang III-IV Alor III-IV Waingapu III-IV Waijelu III-IV Lembata II Ambon II Piru IV Dobo IV Tiakur

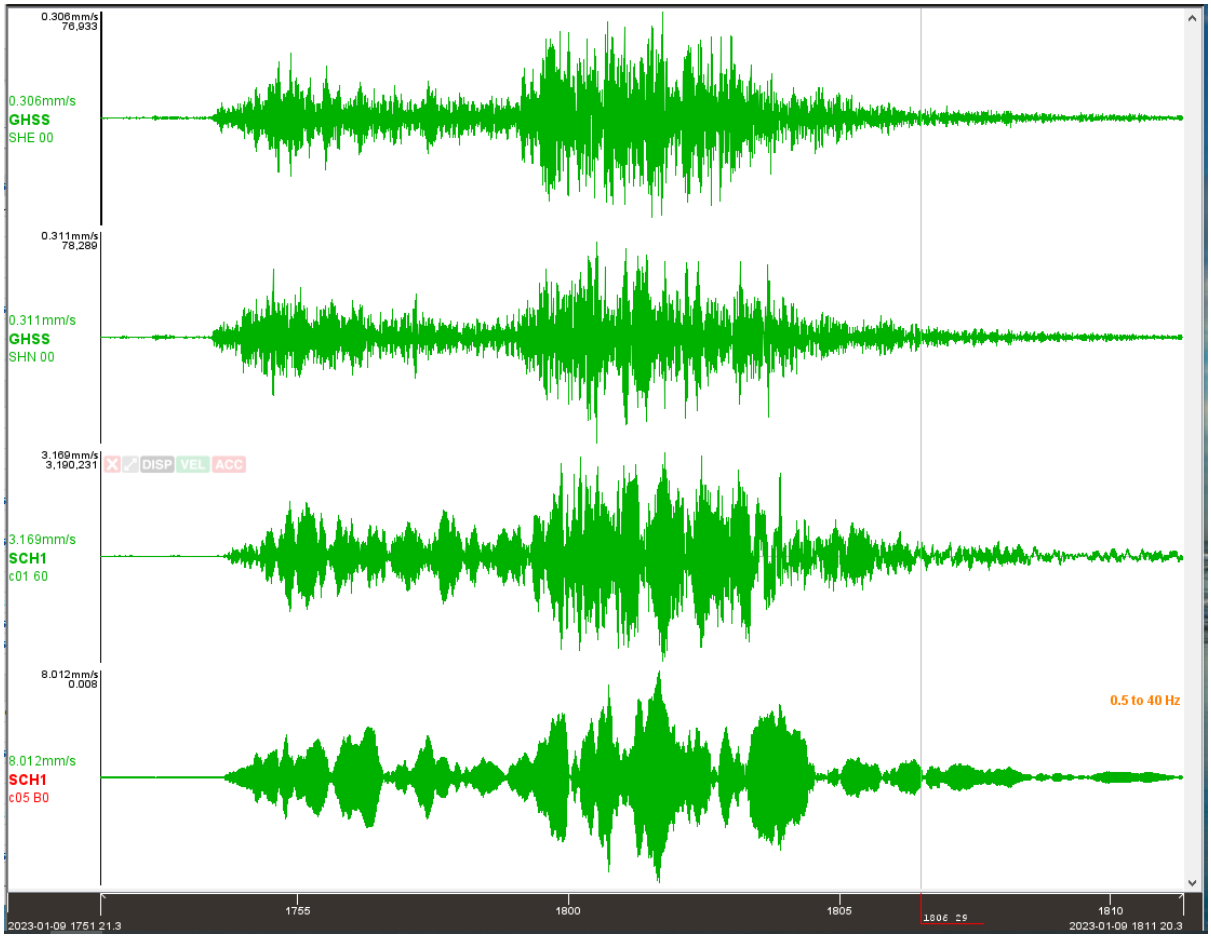
Note Megathrust earthquakes are rare but even great earthquakes north of Darwin have noticeably shaken tall buildings in Adelaide in the past.

Indonesian earthquake recorded in Schulz building

by David Love

In December 2021 we monitored the 12 storey Schulz building at the University of Adelaide. The data were then used by 2 students during their honours project. Late last year a broadband seismometer and accelerometer were installed in the top storey to monitor for a longer period. The instrument has now recorded a number of earthquakes, including the magnitude 7.6 earthquake in Indonesia (2023-01-09) that was felt across northern Australia (see article above).

The 30 second broadband seismometer just clipped in the N-S direction at 1.45mm/sec (or 6.8mm displacement), but the recording on the accelerometer was converted to velocity to give the equivalent waveform.



This figure shows shaking at Government House at ground level GHSS and the neighbouring Schulz building top floor SCH1. E-W and N-S channels are shown as velocity, with peak velocities listed. Red SCH1 is the N-S accelerometer channel converted to velocity.

The building response shows some beating, particularly in the N-S direction, which is the narrow dimension of the building. The peak magnification in the E-W and vertical directions was approximately 10, and in the N-S direction was about 25.

We are discussing with the university some further monitoring in this building.

What constitutes an active fault?

Benedetti et al., in Terra Nova, 15, 118–124, 2003 discuss an episode of activity on the Kaparelli fault in Greece. In February and March 1981, three successive earthquakes occurred at the eastern end of the Gulf of Corinth, their magnitudes 6.7, 6.4 and 6.4. Not unlike the 1988 Tennant Ck earthquake sequence but stretched in time with the largest first rather than last. The third shock on 4 March, Ms 6.4, ruptured the Kaparelli fault. ^{36}Cl cosmic ray exposure dating was used to date episodes of previous activity on the fault. The results suggest that the Kaparelli fault ruptured three times previously; 20±3ka, 14.5±0.5ka and 10.5±0.5ka with slip amplitudes between 0.6m and 2.1 m. Importantly, the Kaparelli fault appears to have been inactive for the ten thousand years prior to the 1981 event.

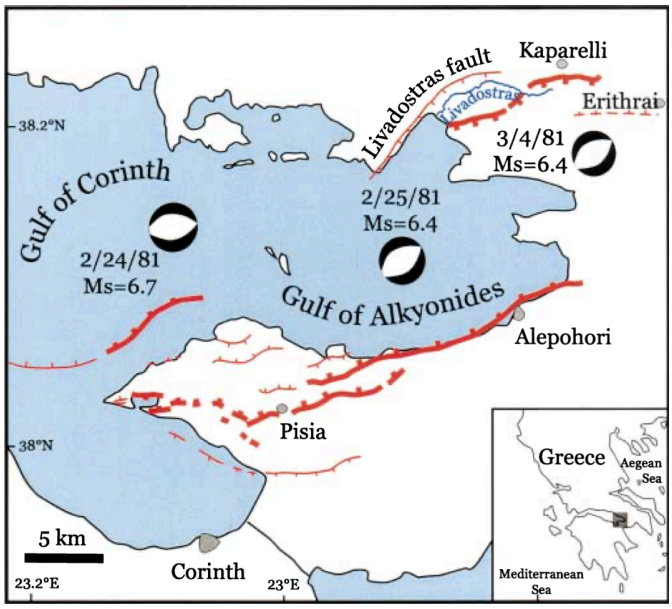


Figure 1 The epicentral region is shown from Benedetti et al, with Quaternary Faults in red, the bold red lines those that are known to have ruptured in the three large earthquakes in 1981.

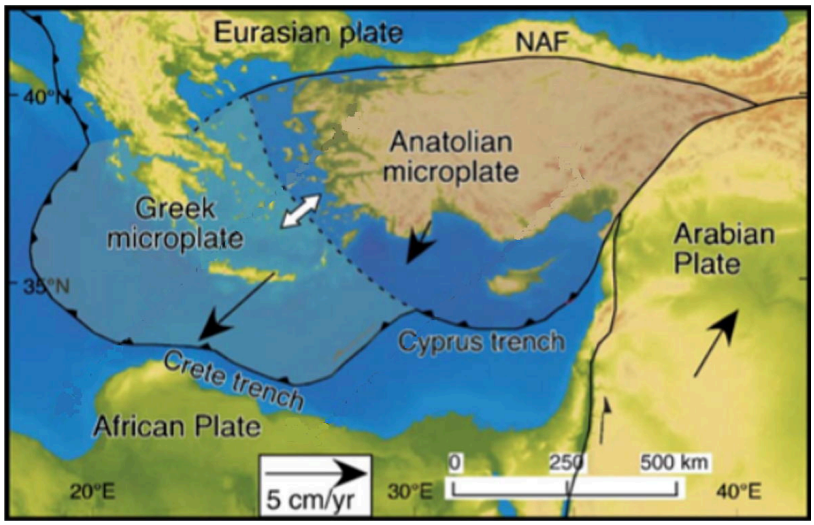


Figure 2 This is an intraplate setting as can be seen in Figure 2 from the USGS. For a location in Figure 2 look at the inset in Figure 1 showing the Peloponnese Peninsula.

So, whilst a rift with so-called normal faulting, the reverse of the situation in most Australian earthquakes, the sequence is of some interest for Australia. In particular it casts light on what might be designated an active fault in an intraplate setting.

Earthquake Engineering/Seismology courses in Australia (Covid disrupted so check with the institution whether the courses advertised on their website will be operational this year).

1. The University of Adelaide offers a graduate course in earthquake engineering. The course provides students with an understanding on the behaviour of structures under wind and earthquake loads. Students will learn concepts and techniques for analysing dynamic response of structures subjected to these loadings, and the aspects of structural design with regard to wind and earthquake loads.

2. Swinburne University of Technology. Structural Dynamics and Earthquake Engineering. This unit provides the fundamental knowledge of the basic science of earthquakes and its effects on the natural and built environment. Basic theory of structural dynamics will be covered. Concepts and techniques of seismic analysis and design will be introduced.
3. University of Melbourne. Earthquake Resistant Design of Buildings. This subject introduces the fundamental concepts and practice of earthquake resistant design of buildings from an international perspective, incorporating consideration of design in regions of low to moderate seismicity such as Australia and in regions of high seismicity.
4. In 2017 The ANU Canberra offered a graduate course in Seismology at the Research School of Earth Sciences. https://programsandcourses.anu.edu.au/2017/course/emsc8002
5. In 2021 UNSW offered a course Earthquake Engineering and Foundation Dynamics. The course is an advanced course in earthquake analysis and design with particular emphasis on foundation dynamics. The course covers the: Principles of engineering seismology, geotechnical earthquake engineering, earthquake engineering, case studies, pathology of geo-structures and concrete structures, strong ground motion and seismic hazard analysis. https://www.handbook.unsw.edu.au/postgraduate/courses/2021/CVEN9526/?year=2021
6. UTS NSW. Structural Dynamics and Earthquake Engineering. This subject introduces students to the concepts and techniques of structural dynamics and their applications in the design and analysis of civil structures affected by dynamical loading such as earthquakes, strong winds and operational dynamic loads.
7. The University of South Australia offers an undergraduate course in Earthquake and Masonry Engineering. The course covers design of reinforced and unreinforced masonry structures for compression, bending and combined actions. Nature and origin of earthquake activity and its consequences on structures. Seismic design and assessment of structures. https://study.unisa.edu.au/courses/106020
8. UniSA also offers a postgraduate course in Structural Dynamics and Seismic Design.
9. The Structural Engineering Design Centre (SEDC) in Sydney was founded by a group of Australian structural engineers with PhD degree in structural engineering. It advertises practical calculations and learning materials with an emphasis on Australian standard codes and current construction industry applications. Basics of Earthquake Eng., Seismology & Seismic Risks $24.99. Basics of Earthquake Engineering, Seismic Analysis Methods, Seismology & Seismic Risks of Built Environments https://sedc.com.au/Courses/CourseDetails?id=14 This course includes the basics of earthquake engineering, seismic analysis methods, seismology, and seismic risks of built environments. For graduate/undergraduate engineers, university students and engineers who are looking to refresh their knowledge.
10. If you know of other courses in Australia at graduate or undergraduate level please advise

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Attention: SAA member ZOOM meeting Monday 13 February at 7:30pm CSST

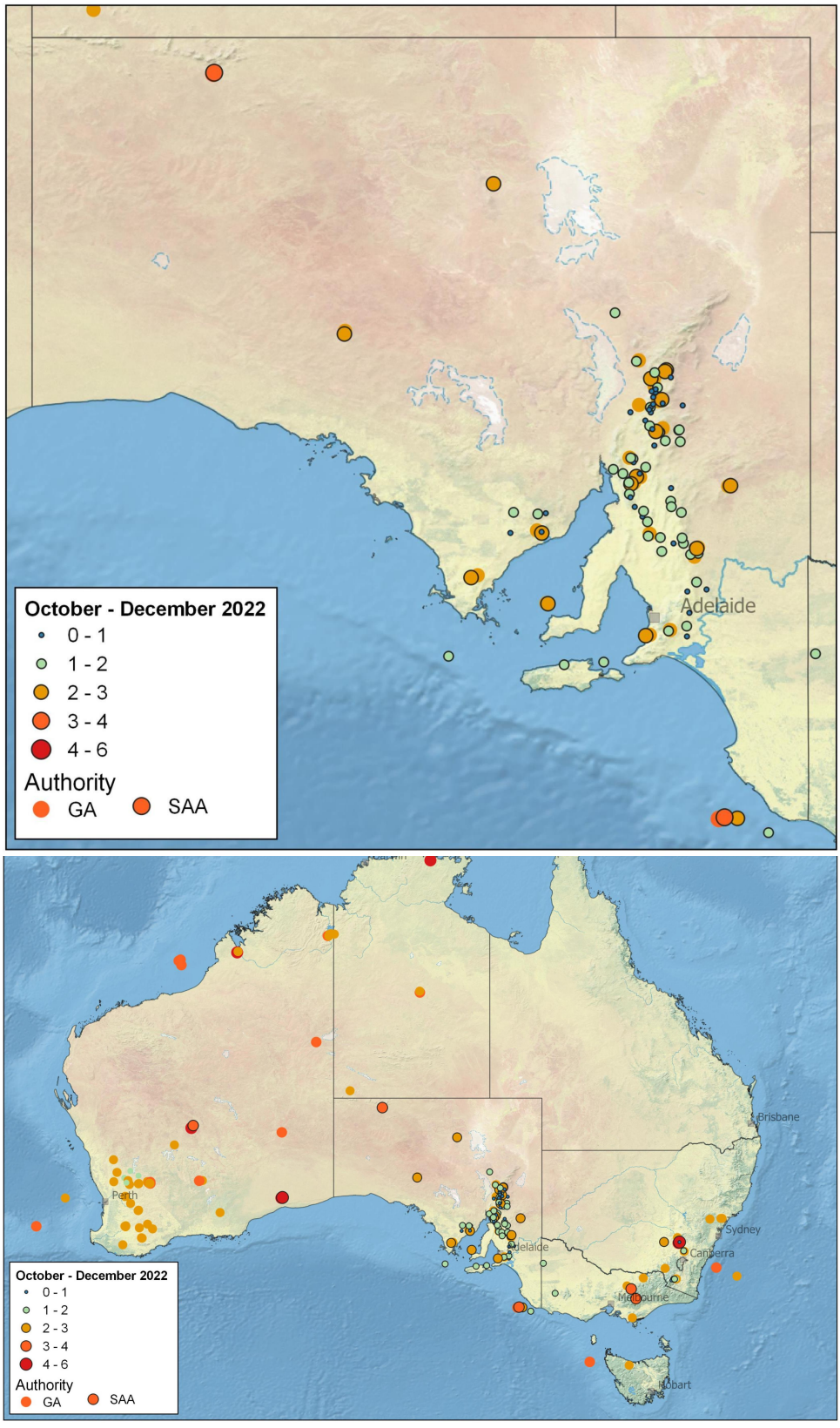

Figure 1 (*Maps created by Clive Collins using a Transverse Mercator projection*). Epicentres of South Australian (above) and Australia (below) earthquakes during October-December 2022 as determined by SAA and Geoscience Australia The largest earthquake in the quarter, M4.6, occurred in southeast WA below the Nullarbor Plain, five of the events exceeded magnitude 4.0. None of the locations are out of the ordinary.