Seismologists and the Adelaide earthquake of 1954: the role of citizen scientists in an AI world.

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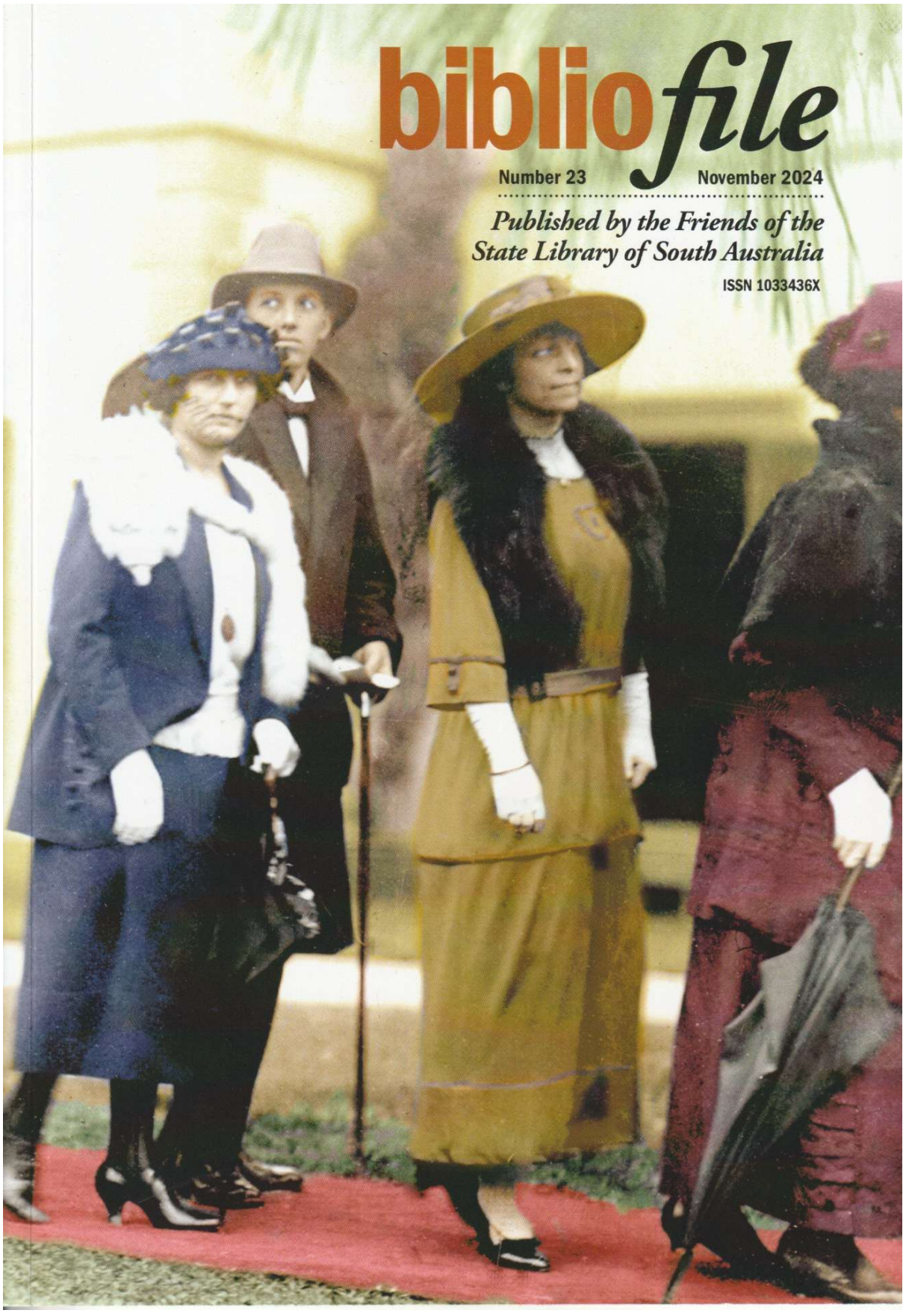

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Seismologists and the Adelaide earthquake of 1954: *the role of citizen scientists in an AI world.*

COL LYNAM

Introduction

I noticed the similarity between our two volunteer organisations when writing this article. The Friends of the State Library of South Australia's fundraising activities assist the preservation of historical collections 'of past, present and future, written, photographic, and audio artefacts, which is an indispensable service in the capture and preservation of every aspect of South Australian life.' (Clark 2020). Similarly, the more recently formed Seismological Association of Australia (SAA) is a group of volunteers with objectives of data recording and preservation. Professional and citizen seismologists and technologists are interested in earthquake phenomena and the building, upkeep and running of seismographs. This includes all the underlying technology required to capture and transmit signals from remote listening locations in South Australia and ensure analysis and preservation of the data is prioritised. SAA currently operates over 20 seismographs in South Australia and assists keeping others running in additional Australian states.

The extra SAA seismographs funded, installed and operated by SAA members mean that more of South Australia's earthquake epicentres can be accurately located (particularly at depth) and reveal more about the direction of movement of the sub-terranean failing faults. The data is freely available (https://earthquakes.mappage.net.au/q.php).

Is Australia likely to have earthquakes?

Yes, because the Earth is constantly subjected to tremendous dynamic forces that place stress on geologic rock formations that give way, eventually. This is understood through Plate Tectonics theory.

In our area, the attached map (Fig 1) shows boundaries of the Indo-Australian plate and the state of stress within the Australian continent. Large black arrows indicate mid-ocean ridge forces, small black arrows indicate forces associated with continental collision and subduction zones, white arrows indicated buoyancy forces resulting from lithospheric density variations, grey arrows indicate mean maximum horizontal stress orientations with the Australian continent (length of bars is proportional to data quality).

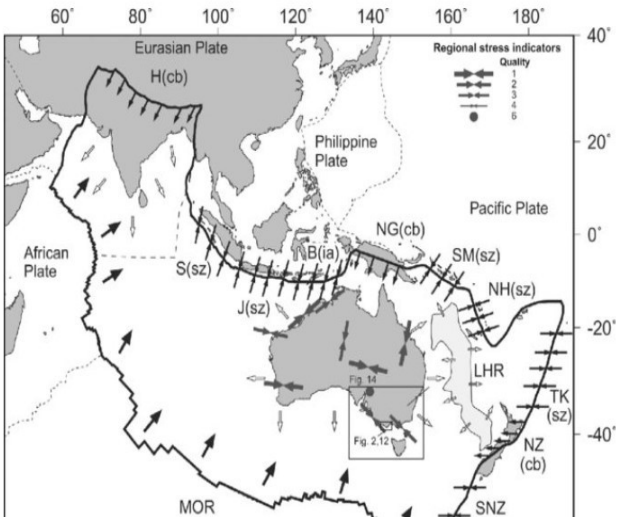


Figure 1 Map showing boundaries of the Indo-Australian plate and the state of stress within the Australian continent (Permission S. Holford).

(**legend** - **H**, Himalaya; **S**, Sumatra Trench; **J**, Java Trench; **B**, Banda Arc, **NG**, New Guinea; **SM**, Solomon Trench; **NH**, New Hebrides; **LHR**, Lord Howe Rise; **TK**, Tonga-Kermadec Trench; **NZ**, New Zealand; **SNZ**, south of New Zealand; **MOR**, mid-ocean ridge; **cb**, collisional boundary; **sz**, subduction zone; **ia**, island arc.)

SAA Member Clive Collins created our interesting set of epicentre maps covering the whole of 2023. The seismometers have been busy.

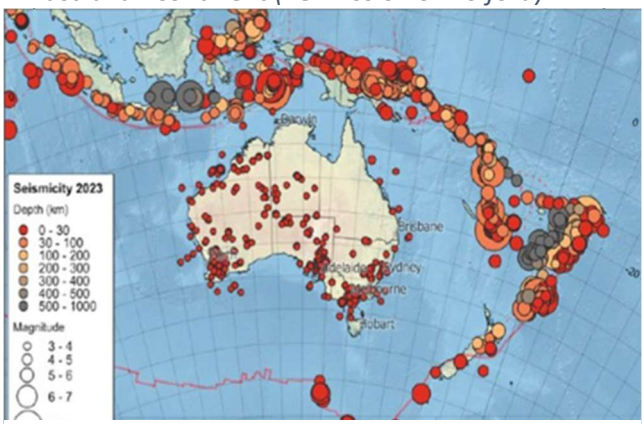


Figure 2 Australian interplate earthquakes in 2023.

(Fig 2) shows continental Australia in its plate tectonic setting. The plate boundaries are the thin, red, solid lines These are the location of the INTERPLATE earthquakes.

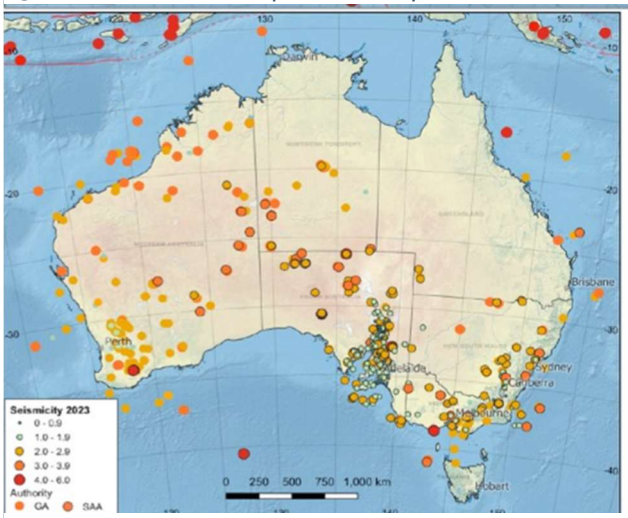


Figure 3 Australian Intraplate earthquakes in 2023.

INTRAPLATE earthquakes (Fig 3) occur mainly in the old, cold continental Australian crust and are smaller and less frequent, whereas the interplate earthquakes (Fig 1) are larger and more frequent and in younger oceanic crust.

The far field subduction earthquakes are placing stress on the Australian continent that eventually create an earthquake.

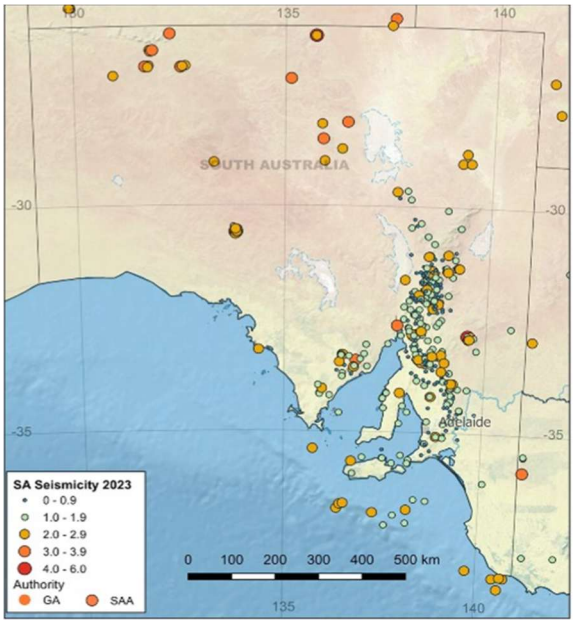


Figure 4 South Australian 2023 earthquakes.

(Fig 4) gives a better spatial location of South Australian earthquake epicentres recorded on our SAA seismographs.

None of the 9 potentially damaging earthquakes in Australia during 2023 of magnitude (M)4 or more, was close to a populous urban area. The year's largest earthquake, of M5.0 to 5.6 occurred near Gnowangerup, WA. It did minor, non-structural damage locally (ceilings down, cracked walls) and shook some residents of high-rise buildings in Perth. (See article in SAA Newsletter #4 2023).

So, yes, we should be prepared for another earthquake, however big.

The Adelaide 1954 earthquake (via the SAA website repository)

SAA member Kevin McCue (2023) has recently revised the 1954 earthquake's description, citing all the newspaper articles that documented the '1954 02 28 18:09:53 UTC, Adelaide mainshock' from which I excerpted the following material. Such data is of interest to earthquake engineers and the insurance business, as well as seismologists and historians:

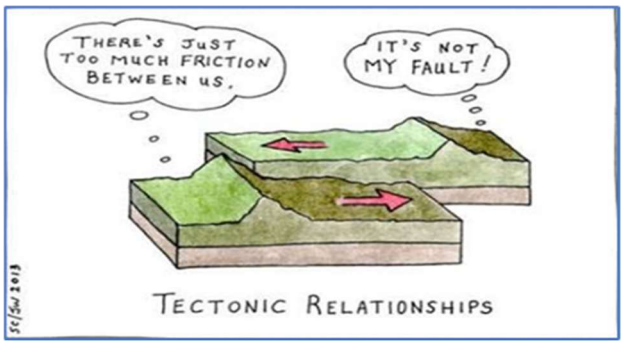
> *At about 3:40am on Monday morning the 1st March local time, a strong earthquake shook the southeast of South Australia causing extensive damage in Adelaide, and costing insurance companies more than £3M (30,000 claims). Damage to houses appeared to be particularly severe in and around the foothills. Four people were injured but miraculously there were no deaths. Extracts from local newspapers made available on-line by the Australian National Library's trove are presented to give the reader a feel for the earthquake and then the issues of where and how big it was are discussed.*
>
> *The ground shaking in the city was strong, with descriptions of walkers nearly thrown off their feet and damage to homes, commercial buildings, and churches. Chimneys collapsed and windows were broken. Several close calls are recounted of people escaping serious injuries. Masonry structures and plaster ceilings performed badly. Many homes and buildings were constructed of clay bricks and sandstone blocks, very attractive but practicable with scarce timber. Government House, home to the Queen during her imminent visit from 18th to 25th March, required urgent, and no doubt, highest priority, repairs.*

The felt area (Fig 6) suggests a magnitude of about 6.0. This location near Darlington close to the Eden Burnside Fault with no surface rupture restrains the focal depth to at least 10km.

Figure 5 Photos of damage in Adelaide taken soon after the earthquake. The widespread use of unreinforced masonry, and damage, are very like that in Newcastle NSW following the M5.6 earthquake there in December 1989. In Newcastle many different assessors judged the maximum intensity at MMVIII and likewise in Adelaide. (McCue 2024)

The fault area of a magnitude 6 earthquake is about 10km x 10km, indicating a source region rupturing from below the surface to 10 km or more deep depending on where it commenced. Recent studies have confirmed observations made by university and government geologists in 1954, that the earthquake generated no movement on the fault at the surface.

Interestingly, with a comprehensive monitoring network operated by citizen scientists of the Seismological Association of Australia now running in the Adelaide region, small earthquakes there have been accurately located down to 20km or more, about the middle of the Earth's crust in the region.



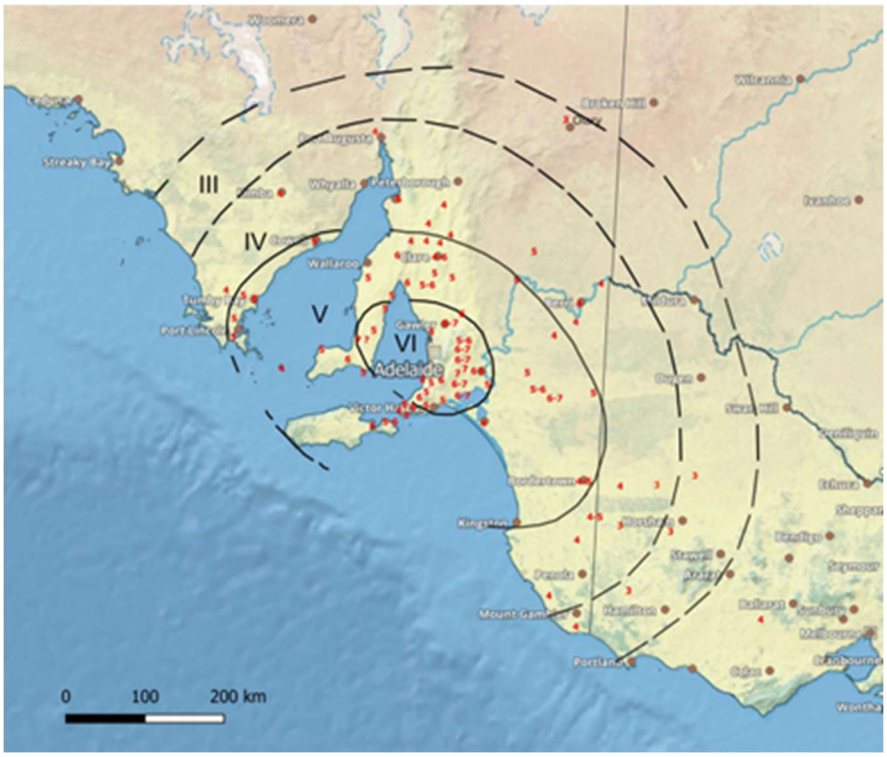


Figure 6 Revised Isoseismal map using Kerr-Grant (1959) and Malpas (1993) felt reports for SA with addition of felt reports in Victoria and NSW using TROVE. (Map compiled by Clive Collins).

The isolines drawn on this map are referred to as Modified Mercalli Isoseismal Intensities. They are derived from reports by humans or inferred from reported infrastructure damage. The scale of MM I – MM XII, states the observed nature of the shaking/ damage, somewhat like this:

> ***MM VI.*** *Felt by all, indoors and outdoors. Frightened many, excitement general, some alarm, many ran outdoors. Awakened all. Persons made to move unsteadily. Trees, bushes, shaken slightly to moderately. Liquid set-in strong motion. Small bells rang - church, chapel, school etc. Damage slight in poorly built buildings. Fall of plaster in small amount. Cracked plaster somewhat, especially fine cracks chimneys in some instances. Broke dishes, glassware, in considerable quantity, also some windows. Fall of knick-knacks, books, pictures. Overturned furniture, in many instances. Moved furnishings of moderately heavy kind* (Wikipedia, 2024).

Sinadinovski et al (2006) suggest that it was the Burnside Fault- Eden Fault that failed and released that earthquake energy. In 1996 a confidential insurance report suggested a recurrence of this earthquake would expose 94,865 flats and houses and the damage could be estimated as $606 million.

A recent study (Martin et al, 2022) suggests that the 1954 Adelaide earthquake was more likely to be near Mt Barker and at greater depth. This was based on reviewing reports of shaking in the hills, particularly changes in springs. Against this is the work of Kerr-Grant (1956) and the location of an aftershock, suggesting an epicentre nearer Adelaide. Unfortunately, it is not now possible to ask Kerr Grant to provide more information. This shows the back and forth of scientific investigations with conflicting information. The Adelaide 1954 earthquake is also notable for the discrepancy in magnitude between the reports from people (suggesting M 6) and the few instrumental records (suggesting M 5.4).

Where did all this earthquake data come from in 1954?

SAA President Dr David Love explains:

> *Before instrumental records*, *newspapers recorded valuable descriptions of local earthquakes on which maps and magnitudes have been based. There were also postmasters' reports sent over the telegraph under the direction of Charles Todd, who established the first seismograph station in Adelaide in 1909. A more sensitive* (seismic) *network begun in 1964 by the late Dr David Sutton of the University of Adelaide, was gradually expanded to 22 seismographs, and managed by the government of South Australia.*

The now defunct Geological Survey Department passed control of those stations over to SAA.

President David Love (Greenhalgh et al, 1994) wrote that the seismic network has allowed the overall pattern of seismicity within South Australia to be determined. The main zones of activity are the Flinders—Mt. Lofty Ranges, Eyre Peninsula and the Southeast. About 400 earthquakes are located each year. The level of activity is relatively low, with only 40 earthquakes of M4 or greater occurring in the last 30 years. The historical (pre-network) catalogue of South Australian earthquakes includes only ten entries for magnitude greater than or equal to 5, the largest being the Beachport earthquake of 1897 (M 6.3). There are only six earthquakes for which focal mechanisms have been determined. The predominant stress appears to be northeast— southwest horizontal compression.

The seismology reports are examples of the classic 'analog era' of earthquake monitoring and detection. They focus on the scientific investigation of how and when an earthquake happens. The number of focal mechanisms has been steadily increasing with the much-improved network of the last 18 years. One hopes modern improvements will continue.

What captivates SAA citizen seismologist members?

Figure 7 Alison Wallace, Member

Member Allison Wallace's recollections in the 2017 SAA Newsletter (SAA 2017, Vol 1):

Over the last 12 months we have located 674 events, and of these 40 were felt events. The largest was a mag 4.9 event offshore from Flinders Chase, which was widely felt across Kangaroo Island. There have also been a number of earthquakes near Adelaide, the most notable a mag 4.0 near Murray Bridge in February 2017 and 10 days later a mag 3.0 at Flagstaff Hill. There was also a small event mag 1.9 near Adelaide Airport. All of these were felt. Initially, I began at Adelaide then Flinders Universities. Then, after 2 years started at the Department of Mines and Energy where we have been until now. When I first began, we had about 12 pen and ink stations and epicentres were located on a Data General Nova3 computer at the rate of about 2 locations a day. Now (before the closure of the network) we have 22 digital stations with epicentres computed within minutes. Hopefully I will still be able to contribute to the State's Earthquake catalogue through the Seismological Association of Australia.

Figure 8 SAA members Blair Lade and David Love installing a seismograph to record aftershocks on the day after the recent Jamestown earthquake (17th April 2024).

Members Blair Lade and David Love are the 'earthquake chasers' setting up a temporary station (Fig 8). Fieldwork is an important role for SAA members. When a local earthquake occurs, we watch out for aftershock events. Installing additional, temporary seismographs assists, to record these smaller aftershocks on the day after the recent Jamestown earthquake on 17 April 2024 (Fig 9). This should enable an accurate depth to be computed for the event, and possibly a focal mechanism to show the direction of Fault movement.

The last 7 years of activity (SAA results) are shown (Fig 9) with the red dot in the centre being the recent magnitude 4.2 event at Jamestown.

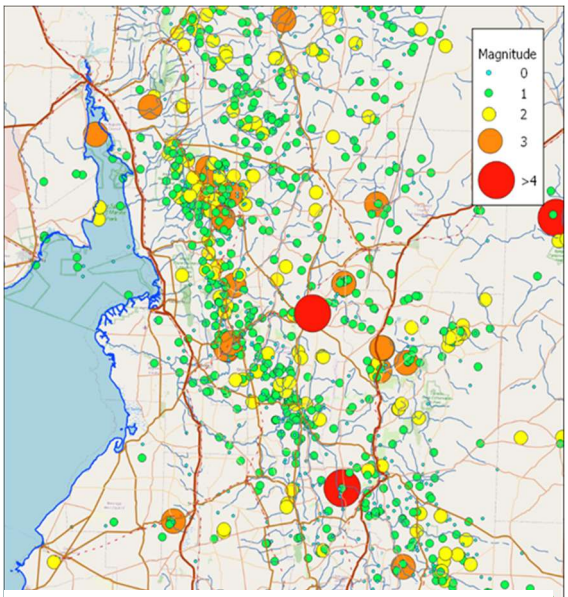


Figure 9 showing 7 years of epicentres. Red dot in centre is the recent Jamestown earthquake (17th April 2024).

Citizen seismology is a growing part of a global movement, now referred to as Citizen Participation throughout the physical and biological sciences, and the social sciences. All these efforts can be harnessed by government policies on the Environment and Climate Change, if chosen.

Increasingly, some researchers are designing for citizen involvement in measuring the effects of Science and Technology on Society (STS). It is surprising that recently the reverse is happening within universities. Post-Covid downsizing of universities and casualisation of academic staff is possibly contributing to a knowledge malaise in the earth science and environmental teaching and research sector. There is now a paucity of extension projects to future manage citizen science.

Australian volunteer Learned Societies (Wikipedia b, 2024) such as Royal Geographic Society of South Australia, collected and shared knowledge like the 'Facebook' of the pre-internet era. They continue to discuss and dissect ideas freely. SAA is such a body for earthquake knowledge gathering and practice. It would seem they are the only long-term operating organisation utilising naturalist or volunteer activity in this area, along with older, self-organized citizen 'public seismic networks' (PSN).

By contrast, there is a globally growing commercial seismograph manufacturer and computer software retailer, Raspberry Shake, which is very appealing to amateur citizen seismologists and schoolteachers. Its stated mission is to 'become the largest publicly available streaming seismic network in every country'. This commercial venture proves the increasing interest of citizens in becoming amateur seismologists. There are 58 citizen-run Raspberry Shake seismometer systems running in Australia. SAA is using these to contribute to earthquake location.

New methodology evolving globally

New methods of tracking earthquake effects on people are evolving through the development of applications that use Artificial Intelligence (AI). An example is shown through an 'event' analysed by the Euro-Med Seismological Centre (EMSC, France) narrated by Prof Remy Bossu (2023):

On Friday 12 May 2023, at 18:35 UTC (22:30 local time), EMSC noticed a sudden increase in traffic on its website, traffic originating from the United Arab Emirates (Figure 10). Such increases (called crowdsourced detections) are typically observed after an earthquake, when eyewitnesses rush to the Internet to find out the cause of the shaking they have just experienced. But what caused this shaking? That's where the Seismo detectives come in!

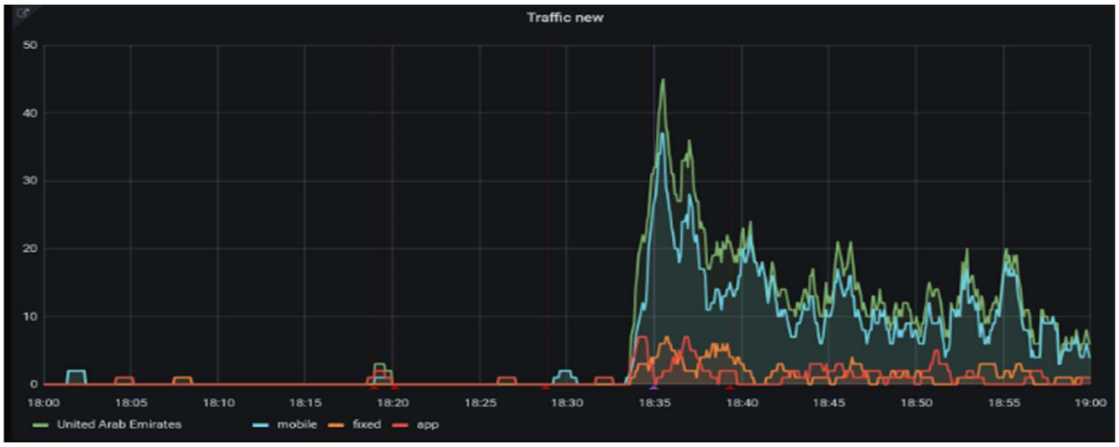


Figure 10 Rapid increase in traffic to EMSC website originating from the Emirates is detected on 12 May 2023.

At EMSC, one of the world's major earthquake information centres, we have been using traffic surges for over 15 years to quickly detect felt earthquakes, regardless of their magnitude. We monitor traffic to our website, our LastQuake smartphone app, and the number of tweets containing the keyword 'earthquake' in different languages. The beauty of these detections is that they are very fast (15 to 90 seconds after the quake) and precede seismic detections!

Eventually, we learned that the shaking had been caused by the overnight demolition of a building, a demolition that had not been announced to local residents (and many of the tweets explaining it have since been deleted).

Rapid earthquake damage assessment

All measurement of parameters in an earthquake event is challenging because of many sources of uncertainty. But there is a 'shortcut' solution. Bossu (2023) states that by using the felt reports crowdsourced by the EMSC after the devastating M7.8 earthquake in Turkey in February 2023, and incorporating them into the USGS PAGER system, the result would have been a fatality estimate within 10 minutes of the earthquake (15 minutes if computation time is added). It would have been consistent with both the final PAGER alert level and the reported death toll, both of which were not known until days later.

The era of 'big data' is here for detection and recording disaster effects of large earthquakes. The big insurers are mobilised. I read that

'The vulnerable, highly concentrated building stock has the potential for extreme losses. A repetition of the 1954 Adelaide earthquake (magnitude 5.7) would result today in multi-billion insured losses. A bigger event closer to Adelaide could cause a loss costing tens of billions.' (Allmann, 2015)

Conclusion

After you feel and reflect on the next tremor, you will have an idea of what our volunteer SAA seismology group has achieved. As SAA Chairman Blair Lade asked: 'What are we about?'

- We want to promote and engage in the science of seismology and the recording of earthquakes in Australia by persons so inclined, be they professional or amateur.
- We want to advise and assist people with what equipment to obtain, how to set it up and where to send the data so that it can be useful and fill in gaps within the existing monitoring systems across Australia.
- We want to run workshops, design and build instruments and recording hardware.
- We want to continue to provide demonstrations and training to people and organisations such as schools that are interested in recording earthquakes.

While some of the above are well catered for by commercial entities, information and assistance for the amateur and secondary educational sector is lacking in Australia and it is here that we really can make a difference.

We have surpassed these gaols and I have enjoyed writing a not too 'pompous' article about our 'circumstances' for our fellow volunteer-historian group. I hope you now know more and where to find the real 'measured' and 'treasured 'information about South Australian earthquakes.

I conclude with a 'preparedness warning' for you to take home. **Planet earth rocks!**

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To be incorporated into *Notes on Contributors* page

Col Lynam Is a Queensland Member of the Seismology Association of Australia Incorporated and writes for pleasure as a citizen science author. He is a volunteer Vice-President of the Royal Society of Queensland and a former Seismograph Technical Officer for the University of Queensland.

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