SAA Newsletter

Peismo

#4/2024

From the Editor We encourage members to submit articles with an earthquake connection of interest to members. They may be edited or not published, at the discretion of the editor. Contributions to: mccue.kevin@gmail.com

Contents

Major Earthquakes Worldwide, July - September 2024

According to the USGS, four earthquakes of magnitude M ≥ 7.0 occurred in this quarter all of them bordering the Pacific Ocean and three of the four in the Northern Hemisphere (table below).

Some damage was reported and a small 50cm tsunami was triggered by the Kyushu Japan earthquake. There were no reports of abnormalities at the 12 nuclear power plants on Kyushu and Shikoku. The city of Kagoshima is just 4km from the active Sakurajima volcano in the bay, an active volcano that almost constantly emits ash and steam.

Figure 1 Major earthquakes in the 3rd quarter of 2024 from the USGS.

Major earthquakes Worldwide, July - September 2024

Date UTC	Time UTC	Latitude	Longitude	Depth km	Mww	Place
2024-07-11	02-13-19	6.08	123.15	640	7.1	WSW of Sangay, Philippines
2024-07-19	01:50:49	-23.08	-67.84	127	7.4	San Pedro de Atacama, Chile
2024-08-08	07-42-55	31.76	131.52	24	7.1	Hyuganada Sea, Japan
2024-08-17	19-10-27	52.93	160.13	29	7.0	Kamchatsky, Russia

Photo Shortly after the Russian earthquake in August, the Shiveluch volcano off Kamchatka's east coast began spewing plumes of ash 5km into the atmosphere over the far eastern Kamchatka Peninsula (from the Russian Academy of Sciences).

Maps of Earthquakes July to Sep 2024

The first map shows continental Australia in its plate tectonic setting. The plate boundaries are the thin red solid lines (USGS version). We have plotted everything above ~M4.5 on the plate boundary but above M3 intraplate. These limits are about what is practicable with the existing seismograph network. NZ, and the southern boundary of the Australian Plate remain inactive for the moment.

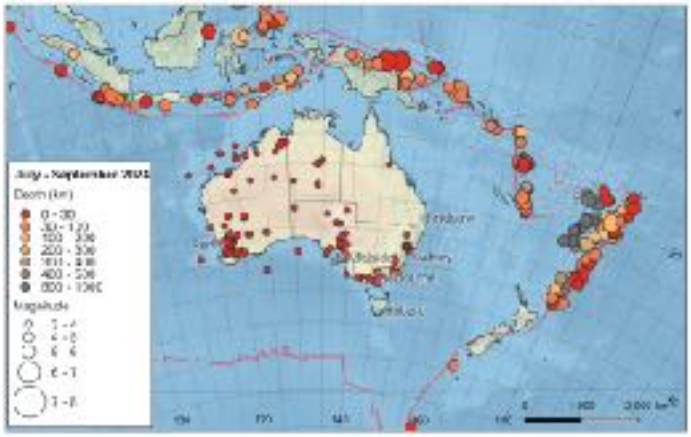

Figure 2 Earthquakes in the Australian region (maps by Clive Collins).

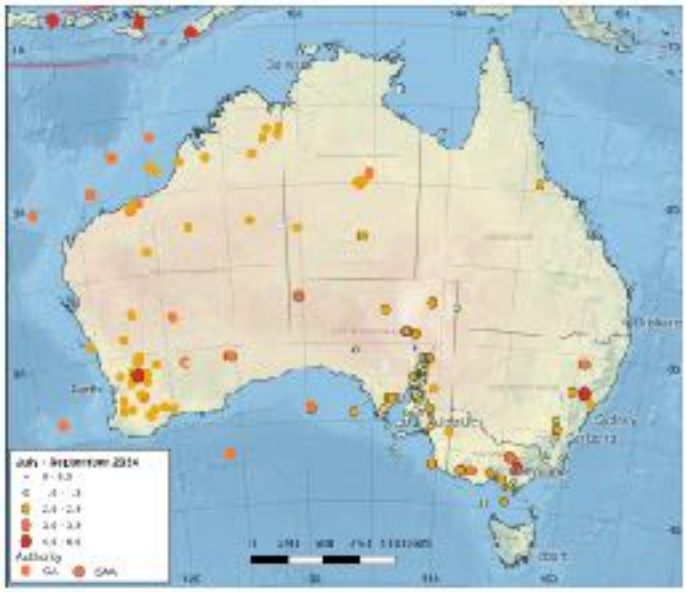

Figure 3 Australian earthquakes

In continental Australia, the largest earthquake in the quarter was the M5.0 earthquake under a coal mine near Muswellbrook north of Sydney NSW at noon

The Seismological Association of Australia Inc.

PO Box 682, Mylor SA 5153

website: https://earthquake.net.au/

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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on 23 August.

Four of the nationwide earthquakes were of magnitude 4 or more. Only the Muswellbrook event caused damage. Unusually the southeast of Australia was the most active area in the quarter.

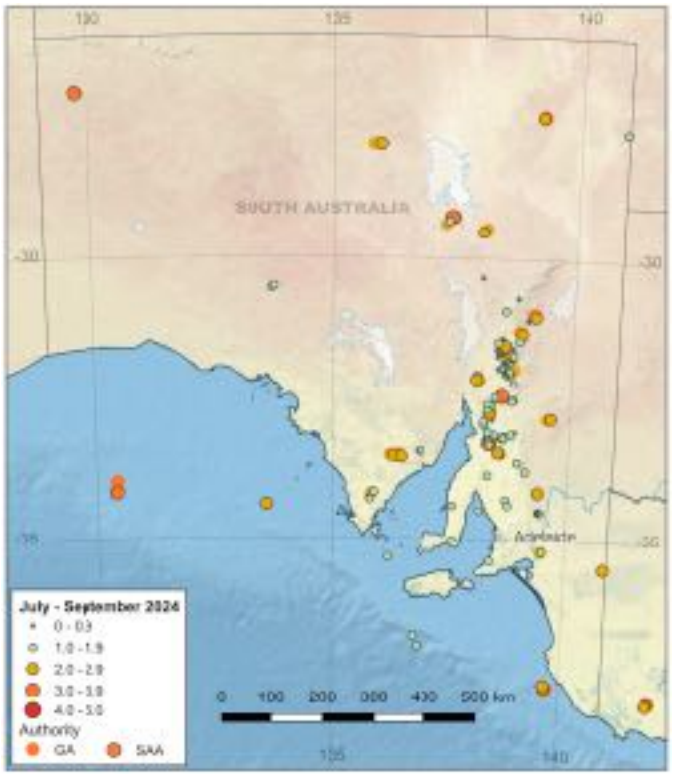


Figure 4. In South Australia, the Adelaide and southeast regions were quiet with no surprises, the historic pattern is stable.

Muswellbrook NSW Earthquakes, Damage and Injuries

A magnitude 5 earthquake struck the mid north coast of NSW about 12:02 on 23 August and was widely felt. It was followed 28 hours later by a magnitude 4.7 aftershock.

The epicentres of both events were directly underneath BHP's Mt Arthur Coal mine, the focal depth very shallow judging by the computed values of 0.5km to 5km and the presence of Rg waves on some seismographs (1 to 5km deep). The epicentre is a few kilometres from the Liddell Power Station, a site where Coalition parties have pledged to build a nuclear power plant.

SAA seismologists's location incorporates closer GA stations plus key data from the Raspberry

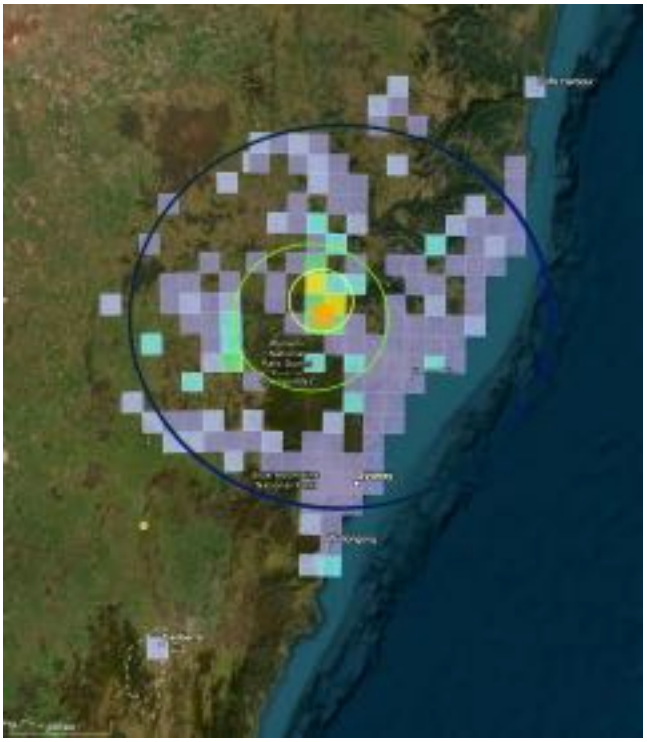
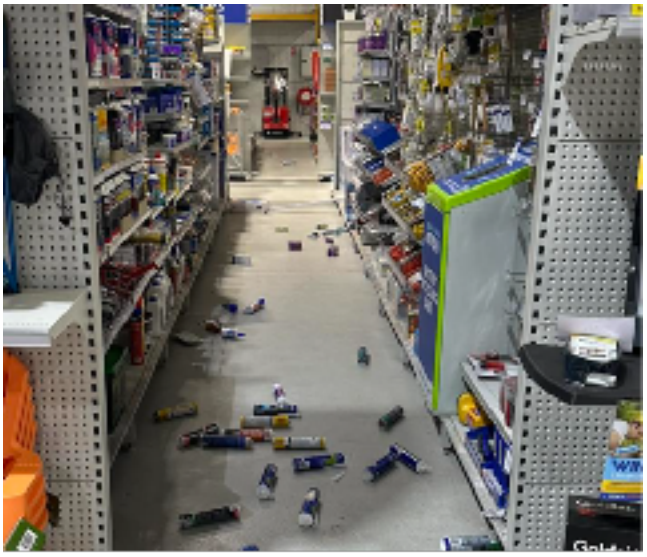


Figure 5 Felt reports of the mainshock with intensity assessments, from GA, contours of MM3, 4 and 5 by the editor.

Shake network and stations operated by Vic Dent and SAA. Shaking in the mainshock was strong in Muswellbrook where a brick chimney collapsed and both M4+ earthquakes were felt throughout Sydney.

Photos (ABC Newcastle: Jesmine Cheong) Goods off shelves in the Muswellbrook Mitre 10 and only one



of several tall chimneys down. (note in the next photos the lack of cohesion between bricks - no or little mortar and certainly no reinforcement.

The Sydney Morning Herald reported that The State Emergency Services were called to help some people who suffered damage to their homes and businesses in Muswellbrook, but there were no reports of serious injuries. Some buildings in Muswellbrook's CBD had broken windows, fallen chimneys and stock spilling off shelves, locals said. At least two public schools were evacuated, A few miners suffered minor injuries from falling items, but no one was seriously hurt, a spokesperson for the company said. The miners stopped work while mining areas within the impacted site were inspected before workers returned.

Panels on the roof of a Muswellbrook Aldi fell, as did stock at a nearby Mitre 10.

The State Emergency Service in Muswellbrook has told NBN News that the earthquake broke the windows at the council depot, with multiple reports of damage to homes, including collapsed chimneys.There were six calls for assistance to the SES in both Muswellbrook and Maitland for minor damage.

Dams in the area were not compromised by the quake, NSW Police confirmed.

More than 2500 customers in Muswellbrook, Denman, Jerrys Plains, Bureen and Bengalla, reported power outages to Ausgrid following the quake, the local power grid was knocked out until 2.30pm.

The mainshock focal mechanisms, from GA, are similar to those of the December 1989 Newcastle earthquake (McCue and Gregson, 1992) and the 1994 Ellalong earthquake (Jones and others, 1994), a shallow thrust, the principal stress direction NE-SW. But the two events may well have happened on conjugate faults approximately north-south and east-west explaining why two similar sized events happened, most unusual for the Newcastle region going back to 1841.

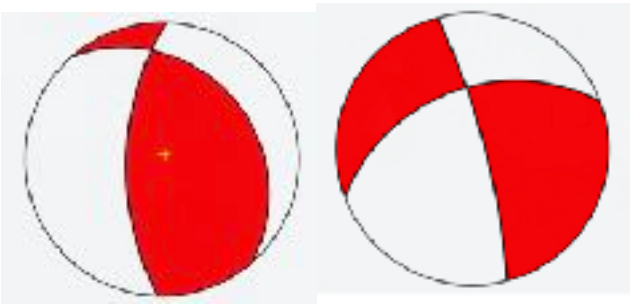


Figure 6 Focal mechanisms by GA for the two larger Muswellbrook earthquakes.

Thirteen aftershocks had been recorded in the first 2 days, magnitudes in the range 2.5 to 4.7.

The magnitude 4.7 aftershock

The earthquake struck at 4:40pm after a series of aftershocks. It shook bricks from a chimney, no cohesion between bricks.

Electricity provider Ausgrid said power to the area was briefly affected but had now been fully

restored. The Muswellbrook Shire Council said some local areas were without water, including Woodland Ridge and potentially areas of Eastbrook Links. They said work was underway to restore supplies, but advised those impacted to contact council.

Muswellbrook local Wayne Toms told the ABC there had been no damage at his place, but it did rattle. "We were just in the house and felt the house shake for a few seconds again, similar to yesterday, but not as strong," Mr Toms said. "No damage here in our house, but walking around there's a few drawers open and there's a few things that have just moved again slightly. I mean the house certainly rattled."

The sentiment was shared by another local, Alyssa Mahony, who posted on social media that she had definitely felt it, but it "wasn't as bad as yesterday". "Nothing fell and broke today and it seemed shorter but we still have power," Ms Mahony said.

Hunter residents from places such as Wollombi, Lower Belford, Cardiff, Cessnock and Warners Bay have also reported feeling the quake. Others in Sydney, almost three hours drive from the epicentre, have also said they felt the quake.

Epicentres near coal mine blasts

On Friday, there was a mine blast scheduled prior to the earthquake, and another again before today's quake.

Speaking to the ABC, Shadow Energy Minister Ted O'Brien said should an earthquake risk be identified in the Upper Hunter in a nuclear feasibility study, then plans for nuclear power in the Hunter Valley would need to be abandoned. "If there is a feasibility study done and that comes back with advice that says any power plant should not proceed, then a power plant would not proceed full stop," he said.

A number of mine workers were treated for minor injuries after Friday's quake, but a spokesperson for BHP told the ABC that no-one had been injured today.They also said BHP had conducted a site-wide inspection and that the tailings dam were unaffected.

The ABC has asked the NSW Resources Regulator about the status of scheduled mine blasts in light of the second quake in the vicinity.

A day after a large earthquake shook a small community in regional New South Wales, Steve Reynolds the Muswellbrook mayor was calling a local rugby league final on Saturday when he felt

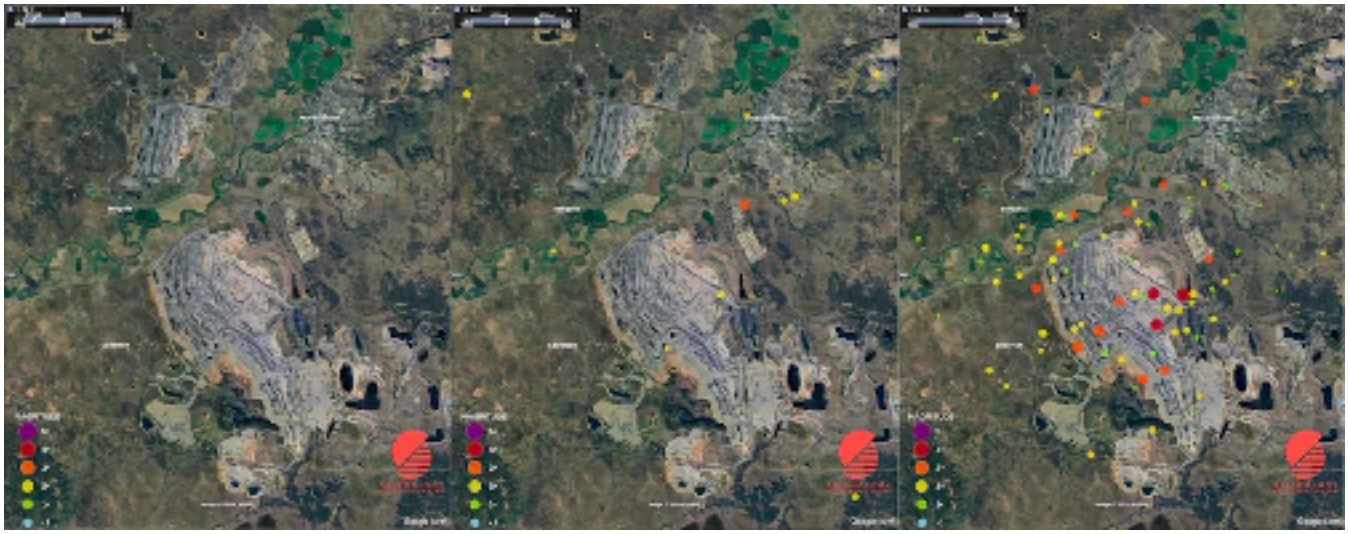


Figure 7 Seismic activity in the Muswellbrook region. Left to right: 1994–2004, 2004–2014, 2014–current. Adam Pascale/ Seismology Research Centre

The figure and following text are from Dee Ninis and Dion Weatherley - The Conversation 27 Aug 2024.

"I thought maybe a fire had started so much dust and a rumble and trees shaking," Ms Martin said. While Scott Taylor, who was on the fourth floor of Maitland Hospital at the time, said it had lasted about 10 seconds.

the commentary truck shake. "We thought someone was playing a joke and shaking the truck," he said. "But no, we experienced another one."
"You don't experience those things in our area, it has not been something that we have been through," Cr Reynolds said.

Amazingly he (and many others) seems to have forgotten the 1989 Newcastle and 1994 Ellalong earthquakes already though they were strongly felt in Muswellbrook.
At the Mount Arthur Coal mine, earthquake monitoring has been ongoing since the 1990s. [SRC monitoring ceased in 2014 according to Adam Pascale]. GA have put in some aftershock kits. While a smaller mine was operational prior to that time, satellite images on Google Earth show a significant expansion – more than double the original mine size – began in 2002. Seismic activity in the region increased from about 2014. This appears to indicate that the crust has been responding to stress changes due to mining at the site.

References

Jones, T.D., Wesson, V., McCue, K., and Gibson, G., 1995. The Ellalong NSW earthquake, 6 August 1994. In: Proceedings of the Australian Earthquake Engineering Seminar, Canberra 14-15 November 1994.
McCue, K.F. and Gregson, P.J., 1992. Australian Seismological Report, 1985. Australia Geological Survey Organisation, Record 1992/100.

The PEISMO rollout continues

Ten additional Peismos designed by Colin Love, (with help from Eric and David Love), construction and layout by John Millard, are on the production line for installation in SA, the ACT, Victoria and possibly WA. Some of them will be available for aftershock recording

Intractable Waste Disposal Facility (IWDF), Mt Walton East WA

https://www.wa.gov.au/system/files/2024-01/iwdf-info-handbook-revision-20.pdf
This author was shocked to hear on the ABC's 7:30 program that a low-level nuclear waste repository exists in Western Australia, and has existed there since 1992. When queried, none of my colleagues including Mundaring seismologists had heard of it either.

The following text was extracted from the Western Australian Government's Information Handbook, the link above.

Background

The IWDF, established in 1992, is Australia's first long-term disposal site for intractable waste. The IWDF is owned by the WA State Government and can only be used for intractable waste generated in Western Australia. The IWDF is about 475 kilometres north-east of Perth and is located on 25 square kilometres of Crown Reserve Land, within the Shire of Coolgardie.

Intractable wastes are materials that are a management problem by virtue of their toxicity or chemical or physical characteristics which make them difficult to dispose of or treat safely. Intractable waste includes radioactive waste which need time to break down or decay to safe levels for the environment, and chemical wastes including industrial by-products like arsenic trioxide, sheep dip and pesticides which contain hazardous chemicals that cannot be easily destroyed.

The IWDF location is at (-30.361524, 120.09026) about 120km NW of Coolgardie. A Google Earth photo is shown in Figure 1, the actual waste dump as shown on the ABC is the white rectangular tent-like structure in the centre of the photo.

Site selection criteria

"The Code of Practice for the near-surface disposal of radioactive waste in Australia (1992) (NHMRC, 1993) defined the site selection criteria for near surface disposal of radioactive waste at the time the IWDF was established. The criteria are summarised as:

- geological stability;
- remoteness;
- arid climate (with evaporation exceeding rainfall by ten times);
- lack of groundwater;

- presence of clay to limit the potential for migration of wastes;
- lack of potential for flooding;
- lack of potential for mineral resources;
- lack of potential for agriculture;
- absence of human population, or potential for human population;
- lack of special environmental features;
- absence of known rare species or ecosystems; and
- lack of special cultural or historical significance.

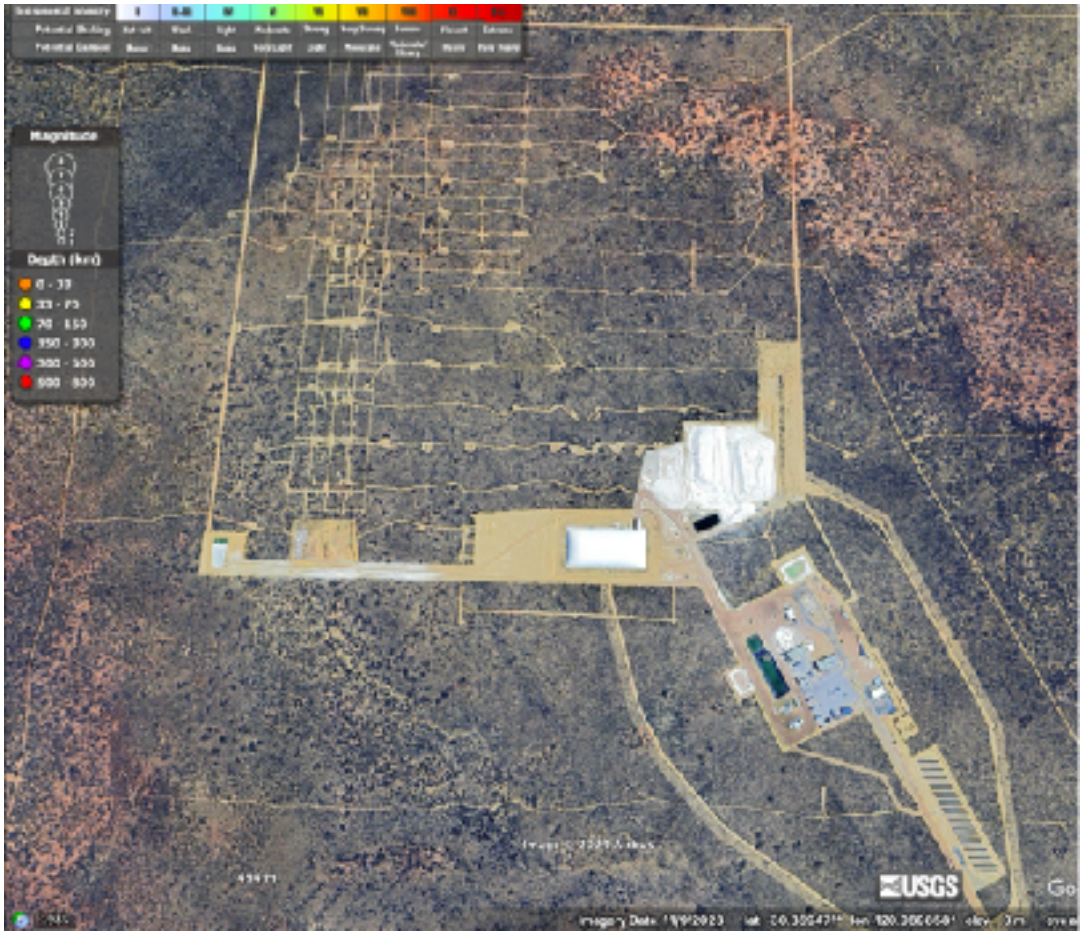


Figure 1 A Google Earth photo of the repository. The large rectangular area shows sampling boreholes connected by E-W access tracks. On the southern boundary is a large rectangular tent-like structure at the end of a broad N-S access track - the current repository. Offices and a large solar array can be seen SE of the repository.

The most recent Code for Disposal Facilities for Solid Radioactive Waste (ARPANSA, 2018) has similar selection criteria.

Geology

The IWDF lies in the central eastern portion of the Achaean Yilgarn Block, a tectonically stable, ancient craton comprising granitic rocks and intervening greenstone belts which contain a variety of volcanic, metamorphic, and sedimentary rocks. *The Yilgarn Block generally has low seismic activity*.

In geological terms the IWDF site is typical of areas overlying deeply weathered granite domes. The profile generally comprises four main lithologies and from the surface these are:

1. Colluvial sand - comprises yellow brown quartz sand overlying nodular red brown clayey sand. It averages about 1.5 metres thick.
2. Silcrete - comprises kaolinitic clay which has been variably indurated with silica to form a hard cap over underlying lithologies. This cap averages about 3 metres thick.
3. Kaolinitic clay - comprises soft white kaolin weathered from pre-existing granite. As a result, the clays contain relict quartz phenocrysts. This important layer houses the buried waste and on average is more than 15 metres thick over the site. It is absent in several areas, especially where the bedrock is shallow, but elsewhere has a maximum thickness of 32.5 metres.
4. Granitoid basement - comprises a fine to medium grained leucocratic granite containing pegmatite and quartz veins. The basement

topography varies over the site from 3.5 to 47 metres below the surface.

The lack of groundwater and the thickness of the kaolinitic clay layer are the key geological attributes of the site in terms of its function as an intractable waste repository because they preclude the transport of contaminants off-site.

The boreholes appear not to have been deep enough to intersect the current groundwater table or basement which makes it impossible to speculate on any impact of water on the waste.

Seismicity

Contrary to it being considered stable, the Yilgarn Block has hosted some of WA's largest earthquakes in historical time and since monitoring began in 1959, is noted for the wide distribution of shallow earthquakes within it. Nobody living in South-west WA in the late 1960s and 1970s could forget the Meckering earthquake sequence, soon followed by other large ground breaking earthquakes like those at Calingiri in 1970 and Cadoux in 1979. A destructive earthquake struck Kalgoorlie on 20 April 2010.

Figure 2 The Yilgarn Block is everything east of the Darling Fault, marked by the dashed yellow line in the Google image above. The white dots are epicentres of earthquakes located by Geoscience Australia in just the last 10 years. The red R is the approximate position of the IWDF.

Looking at the seismicity since 1980, there wasn't much detected near the IWDF (nearest M2.5, 17 km away, in 2014). But within 50 km of IWDF are three neotectonic fault scarps (neotectonics, is the study of the deformations of Earth's crust that are current or Recent in geologic time) : Koolyanobbing Scarp, Seventy-One Mile Scarp, and Clive's Fantasy Fault, the latter described as: "Approximately 20 km long and up to 6 m high west of Kalgoorlie, WA. Scarp occurs close to an AGSO seismic line and its along strike interpolation coincides with a reverse fault imaged on the seismic."

Over the last 100 years some of Australia's largest earthquakes have ruptured the Yilgarn Block, the distance from the IWDF of the Meckering and Cadoux Scarps is about 350km, 10 times the Meckering fault length. The repository would have experienced shaking at MM Intensity 4 during both earthquakes according to the isoseismal maps of Everingham and Gregson, 1970 and Gregson, 1980.
Science does not explain why these earthquakes occurred where they did in the Yilgarn Block, nor why they occurred at this time. Presumably they could have occurred anywhere in the Yilgarn Block at any time, with equal probability. Other Recent fault scarps near the waste facility have been mapped and documented by Geoscience Australia paleo-seismologists over the last 20 years.

Figure 3 Air photo taken by Ian Everingham of part of the 35km long, 2m high, fault scarp formed during the M6.8 earthquake through Meckering WA on 14

October 1968. Meckering township was destroyed and had to be relocated and rebuilt.

Figure 4 (above) A ground level view of the fault scarp, up to 2m high at this point (photo Ian Everingham).

Figure 5 (opposite)The main east-west standard gauge (left) and narrow gauge railways from Perth to Kalgoorlie, buckled where the fault compressed them with both uplift and shear (photo Alice Snooke).

Figure 6 (opposite) One Tree Fault scarp produced during the 2 June 1979 Cadoux WA earthquake (photo WA Newspapers).

It would be interesting to see the formal earthquake hazard analysis of the IWDF site considering the history of strong earthquakes in the Yilgarn Block and very long half life of some of the radioactive substance that might be buried there. Perhaps the earthquake risk for low-level waste is small due to their short half-life but that is not the case for intermediate or high level waste which have to be kept in a stable environment for hundred of thousands to perhaps a few million years, longer than the age of H*omo sapiens (~200,000yrs)*.

A very thorough public earthquake hazard study would have to be done at the site if the owners were planning on upgrading the facility to store intermediate or high level waste.

References

Everingham, I.B., and Gregson, P.J., 1970. Meckering earthquake intensities and notes on earthquake risk in Western Australia. BMR Record 1970/97.

Gregson, P. J., 1980. Mundaring Geophysical Observatory Annual Report, 1979. BMR Record 1980/51.