



The 24 August 2024 Muswellbrook Earthquake Sequence, and Implications for Future Events

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The 24 August 2024 Muswellbrook earthquake sequence included a magnitude M_w 4.7 mainshock and a large aftershock (M_w 4.4) the next day at an almost identical location and depth (6 and 5 km respectively), as shown by the two largest yellow dots on the left side of Figure 1. They occurred near Edderton, about 5 km south-southwest of Muswellbrook and about 125 km northwest of Newcastle in the northern Sydney Basin, shown on the right side of Figure 1. The Hunter-Mooki Thrust (right side of Figure 1), which was an active fault 250 million years ago but is not known to be currently active, forms the eastern margin of the northern Sydney Basin. The fault orientations of the two largest events have implications for the potential for future earthquakes in the northern Sydney Basin. There have been more than 150 events in the region in the last 20 years, with the last significant event a magnitude 4.4 in 2019.

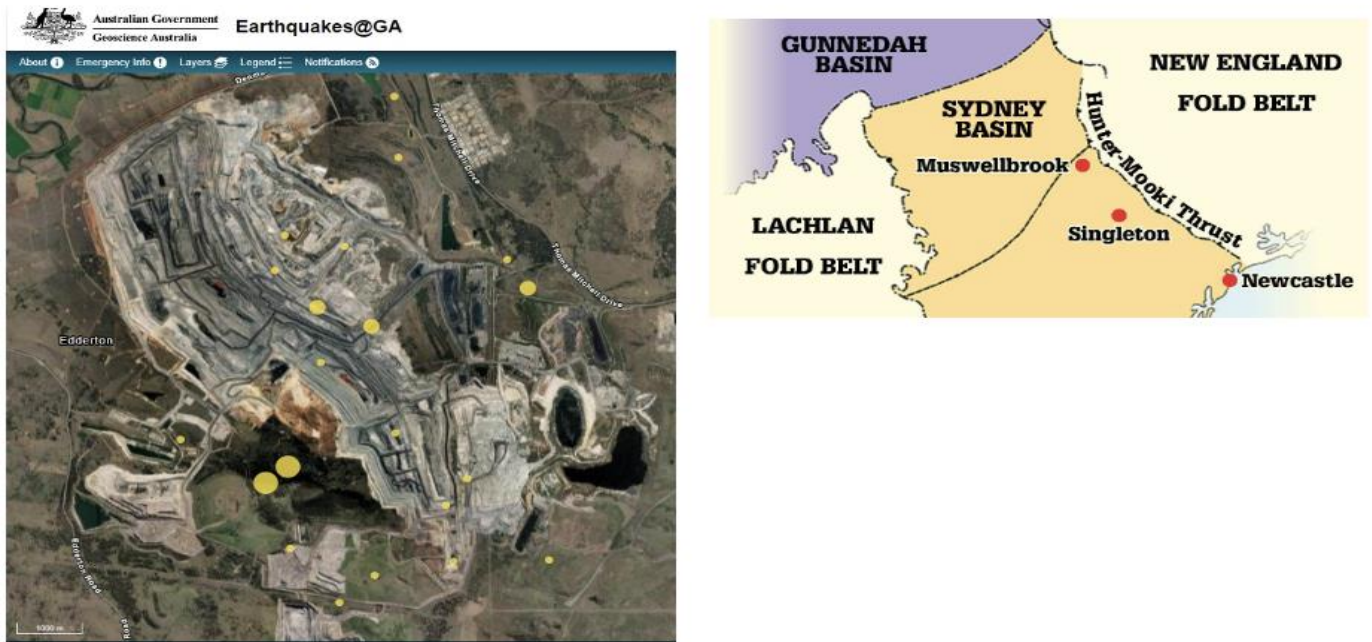


Figure 1. Left: Epicentral Locations of the Muswellbrook earthquake sequence. The scale in the bottom left-hand corner is 1 km long. Source: Geoscience Australia. Right: Location of the Hunter-Mooki Thrust on the northeastern margin of the Sydney Basin.

Impacts of the Muswellbrook Earthquakes

The Muswellbrook earthquakes caused minor damage and disruption to the region. The New South Wales State Emergency Service (SES) received 11 calls for assistance. Minor damage to residential homes included cracked cornices and walls, broken windows, damaged chimneys, screen doors dislodging, and items falling off shelves (Figure 2). St James' Primary asked parents to come and collect their children as the school was without power, and Muswellbrook South Public School was evacuated.

Businesses in the region were also impacted. The Muswellbrook Aldi store had its roof collapse. Similarly, The Reject Shop within the shopping centre Muswellbrook Fair was closed after reports its roof collapsed. Businesses such as the Lavis Mitre 10 in Muswellbrook had stock fall from shelves. The Muswellbrook Shire Aquatic & Fitness Centre was closed for the remainder of the day, and the Muswellbrook council depot was reported to have had its windows broken. Notably, the BHP's Mount Arthur Coal Mine's operations were disrupted as work was stopped following the earthquake. Some of its workers were injured, requiring first aid for minor injuries due to falling items, but no one was seriously hurt.

There was also damage and interruption to critical infrastructure. Thousands of homes within the Muswellbrook Shire Council were left without power. The water infrastructure was also impacted. Muswellbrook Shire Council released a statement that some residents in the Woodland Ridge and Eastbrook Links areas were without water due to a broken water main. Residents were also urged to monitor old aging piping and report any issues so the Muswellbrook Shire Council could fix them to avoid potentially large recovery and repair costs. Dam owners in the region were also urged to ensure that dam integrity has not been affected.

The earthquakes also occurred close to the site of a proposed nuclear power plant, near the Liddell Power Station, which has caused some concern. A feasibility study for such a plant would presumably require a rigorous seismic hazard and risk analysis.

There have also been several suggestions in the media that the earthquakes were the result of mining in the area. These notions are generally thought to be implausible by the seismology community in Australia. Mining blasts generally cause ground shaking at much lower levels than those of this earthquake sequence. Similarly, there were reports that the earthquakes could have occurred at shallow depth due to an altered stress in the crust from the removal of coal at the surface. These mining processes can cause small event less than Mw 2, but studies indicate that even large open pit mines do not appreciably change the stress along faults in the near-surface (within 5km depth) to trigger moderate earthquakes like those in Muswellbrook.

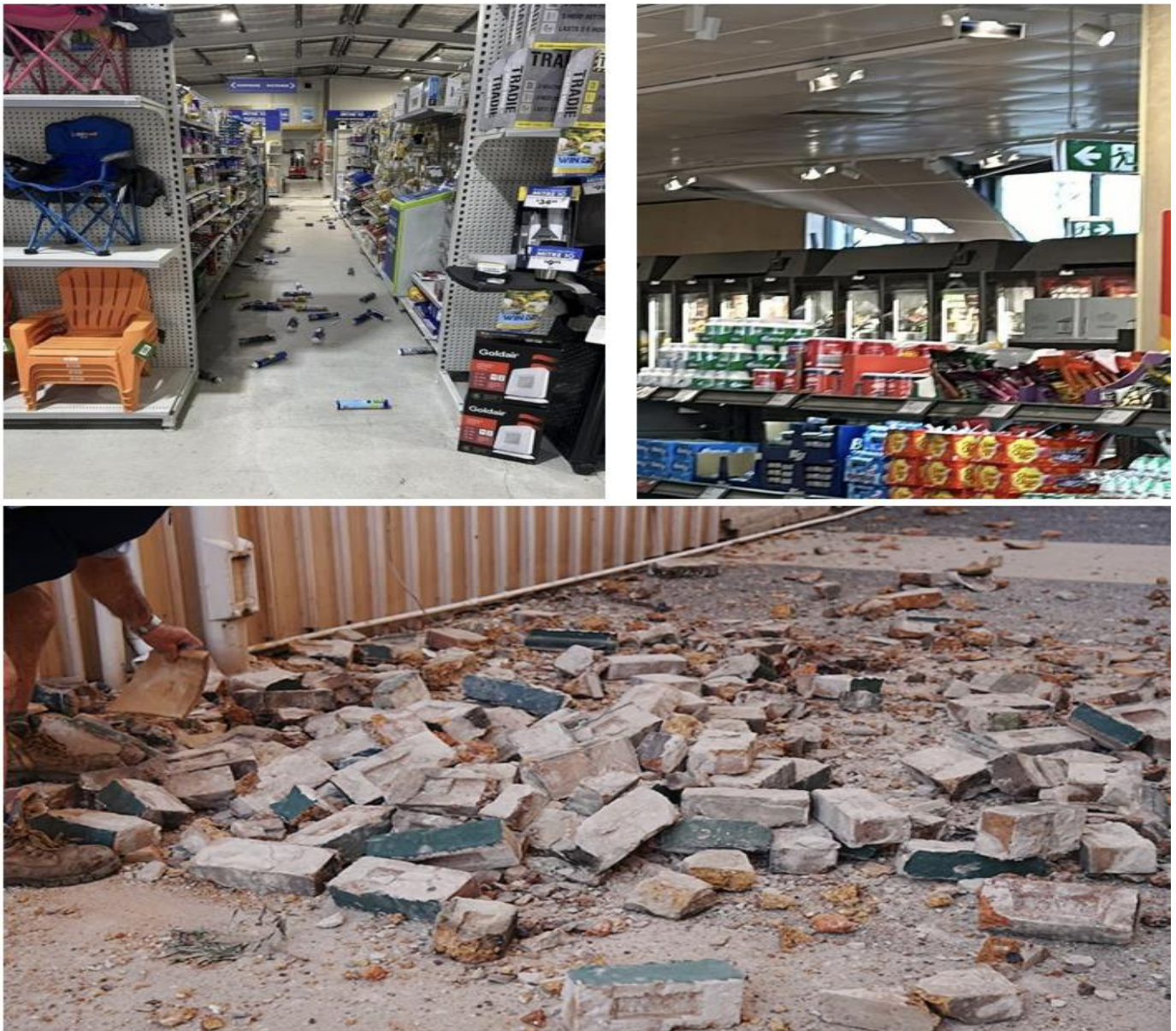


Figure 2. Impacts of the Muswellbrook earthquakes. Top Left: Stock fallen from shelves at Lavis Mitre 10. Source: Facebook/Lavis Mitre 10 Muswellbrook. Top Right: Collapsed roof inside the Muswellbrook Aldi store. Source: Facebook/Dean Reid. Bottom: Bricks dislodged from buildings. Source: ABC Newcastle - Jasmine Cheong.

Fault Orientations of the 24 August 2024 Muswellbrook Earthquakes

The focal mechanisms (describing fault orientations) of the two largest 24 August 2024 Muswellbrook earthquakes are consistent with those of the 1989 M_w 5.42 Newcastle earthquake and the 1994 M_w 4.71 Ellalong earthquake. The focal mechanisms of these events are shown by the beachballs in Figure 3. The beachball is a map that shows the projection of the fault plane on the lower half of a sphere surrounding the hypocenter. It can be visualized by imagining that you are viewing the circular edge of a tilted rubbish can lid (representing a dipping fault plane) from above, as shown in the right panel of Figure 3. The beachballs for all four events indicate reverse (or thrust) faulting on fault planes oriented in a northwest-southeast direction, parallel to the Hunter Thrust Fault, which forms the northeastern margin of the northern Sydney Basin.

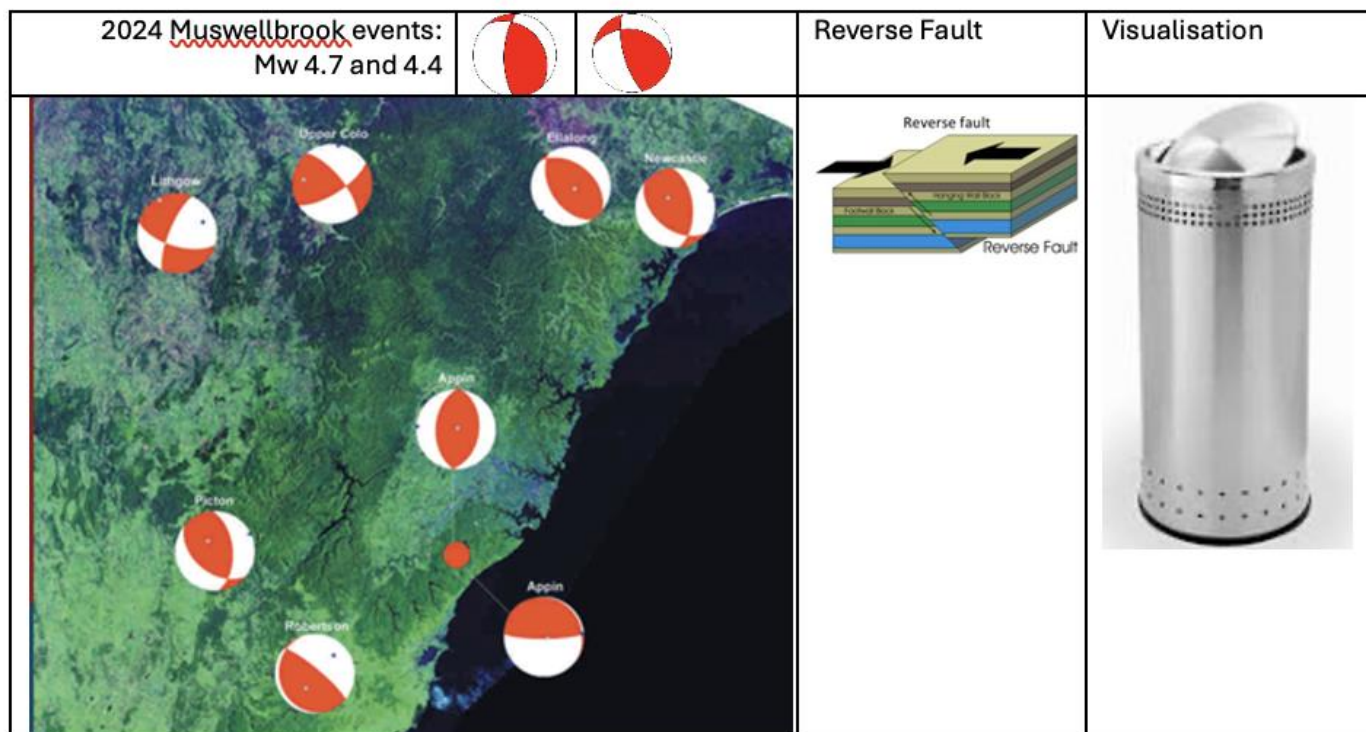


Figure 3. Focal mechanisms of earthquakes in the eastern part of central New South Wales. The two Muswellbrook events at the top, whose focal mechanisms were generated by Geoscience Australia, have been added to the underlying map of Leonard et al. (2002), in which the Ellalong and Newcastle events are shown in the northeast corner. The centre panel shows the mechanism of a reverse (or thrust) faulting earthquake and the right panel shows a visualisation of the beachball focal mechanism of a reverse faulting earthquake.

Implications for Seismic Hazard Levels in the Northern Sydney Basin

As noted above, the 1989 Newcastle, 1994 Ellalong, and two largest 2024 Muswellbrook earthquakes all have fault planes that are oriented northwest-southeast, parallel to the Hunter-Mooki Thrust. The Hunter-Mooki Thrust was active about 250 million years ago, but is not known to be currently seismically active, and does not appear in the Geoscience Australia Neotectonic Features Database or in National Seismic Hazards Assessment (NSHA23, Allen et al, 2023). None of these four earthquakes have been associated with a neotectonic feature or potentially active fault by Geoscience Australia. Nevertheless, this common northwest-southeast orientation of fault planes suggests that these earthquakes may be occurring through the reactivation of segments of the Hunter-Mooki Thrust, and that other segments of the Hunter-Mooki Thrust may also have the potential to be reactivated. As noted above, the Muswellbrook earthquakes occurred about 7 km northwest of the Liddell power station, which has been proposed as a site for a nuclear reactor. Also, it is sometimes suggested that earthquakes in the Hunter Valley region are somehow related to coal mining, but this is generally thought to be implausible by seismologists in Australia.

REFERENCES

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