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The 14 May 2020 Burra Earthquake Sequence and its Relation to Flinders Ranges Faults

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Three earthquakes occurred about 200km north of Adelaide between May 10 and May 14, 2020, as shown on the left side of Figure 1. The first event (yellow), local magnitude ML 2.6, occurred near Spalding on May 10 at 22:53 between the other two events. The second event (orange), ML 2.4, occurred to the northwest of the first event, northeast of Laura on 13 May at 19:18. The third event (red), ML 4.3, occurred to the southeast of the first event at Burra on 14 May at 15:23.

All three earthquakes are estimated by Geoscience Australia (GA) to have occurred at depths of 10 km, consistent with the depth of 7 km +/-3 km for the Burra event estimated by the United States Geological Survey (USGS). The USGS estimated a body wave magnitude m_b of 4.3 for the Burra earthquake from worldwide recordings. Neither GA nor the USGS have estimated its moment magnitude M_w .

The Burra event is the largest earthquake to have occurred near Adelaide in the past decade. People felt shaking in Adelaide office and apartment buildings, as well as in the Adelaide Hills, the Yorke Peninsula and southern Barossa, but it is not known to have caused any damage. Maps of estimated peak acceleration and Modified Mercalli Intensity are shown in Figures 3 and 4 respectively.

The distance between the three events spans about 85 km, and they presumably occurred over a segment of the western range front of the Flinders Ranges. One segment of the range front, formed by the Wilkatana fault (Quigley et al., 2006), is shown on the right side of Figure 1. The occurrence of the three events close in time suggests that they are related to a large scale disturbance in the stress field on the range front faults, because individually the dimensions of the fault ruptures (about 1 km for the Burra earthquake and 200 m for the two smaller events) is much less than their overall separation of 85 km, so they are unlikely to have influenced each other.

There is no indication that a larger earthquake is about to occur, but if a 100 km length of the western range front of the Flinders Ranges were to rupture, it would have a magnitude of about M_w 7.3. Repeated large earthquakes on both sides of the range fronts have raised the Flinders Ranges and Mt Lofty Ranges by several hundred metres over the past several million years (Sandiford, 2003; Figures 2 and 5).

Until the occurrence of the 1989 Newcastle earthquake, the 28 February 1954 Adelaide earthquake (left side of Figure 5) was Australia's most damaging earthquake. Its estimated magnitude has varied between 5.6 and 5.4 until the release of the 2018 National Seismic Hazard



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Assessment (NSHA18) by Geoscience Australia (Allen et al., 2019). As part of that assessment, the local magnitudes ML in the Australian earthquake catalogue were revised and converted to moment magnitude Mw (Allen et al., 2018). On average across Australia, this resulted in a reduction of 0.3 magnitude units, but the magnitude of the 1954 Adelaide earthquake was reduced much more, to a moment magnitude Mw of 4.79.

The 1954 Adelaide earthquake is thought to have occurred on the Eden-Burnside fault that lies just east of Adelaide. As shown on the right side of Figure 5, the Eden-Burnside fault is one of several faults on the western flank of the Mt Lofty Ranges that are uplifting the ranges. No lives were lost in the 1954 Adelaide earthquake and there were only three recorded injuries. Many houses were cracked, and heavy pieces of masonry fell from parapets and tall buildings in the city. One of Adelaide's earliest buildings, the Victoria Hotel, partially collapsed. Other major buildings that were severely damaged included St Francis Xavier Cathedral, the Adelaide Post Office clock tower and a newly completed hospital in Blackwood, which sustained major damage to its wards and offices.

Risk Frontiers (2016) estimated the impact of a magnitude 5.6 scenario earthquake on the Eden-Burnside fault based on the 1954 Adelaide earthquake, and found the scenario's losses to be much larger than the adjusted historical losses for the 1954 earthquake. With the revision of the magnitude of the 1954 Adelaide from 5.6 to 4.79, we now understand the cause of the large discrepancy in losses.

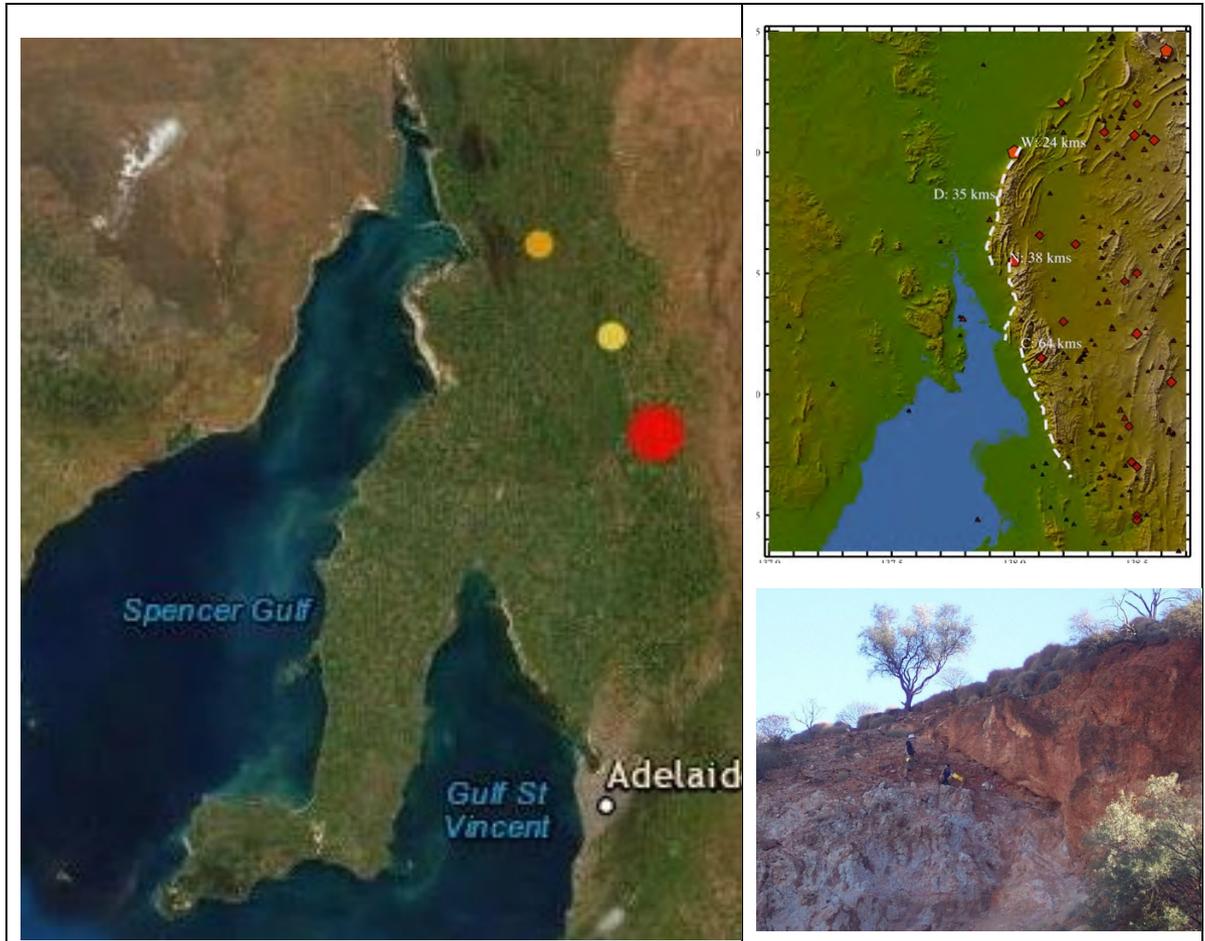


Figure 1. Left: Locations of the earthquake sequence, from top: Laura (orange), Sperling, yellow) and Burra (red). Source: Geoscience Australia, 2020. Top Right: Segments of the Wilkatana fault (dashed yellow lines). Source: Quigley et al., 2006. The Laura event is near the southern end of the Wilkatana fault, and the Sperling and Burra events are off the southern end of the Wilkatana fault on an adjacent segment of the range front fault system (not mapped). Bottom Right: My relative Jonathan Teasdale looking down a fault that dips down to the east (right) at about 45 degrees (black line) in the Flinders Ranges, raising the mountains on the right (east) side. The two sides of the fault are converging towards each other due to east-west horizontal compression, with the west side moving east and down, and the east side moving west and up.

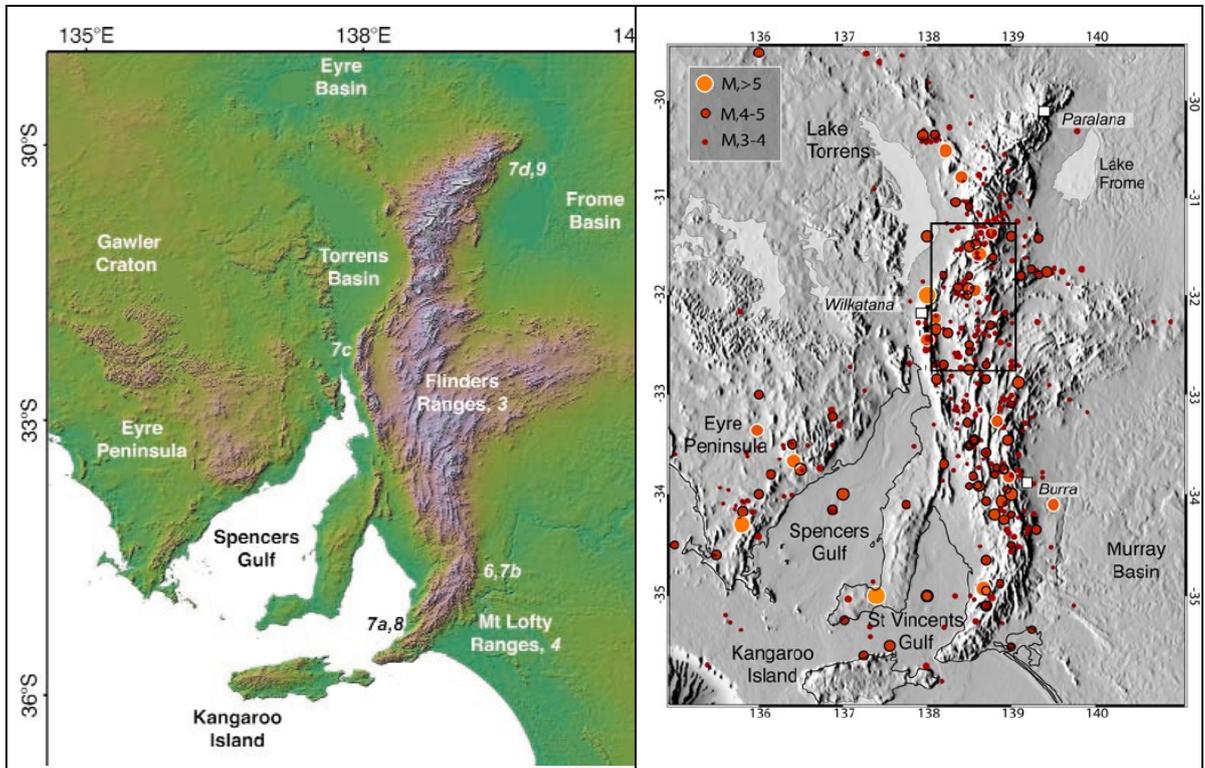
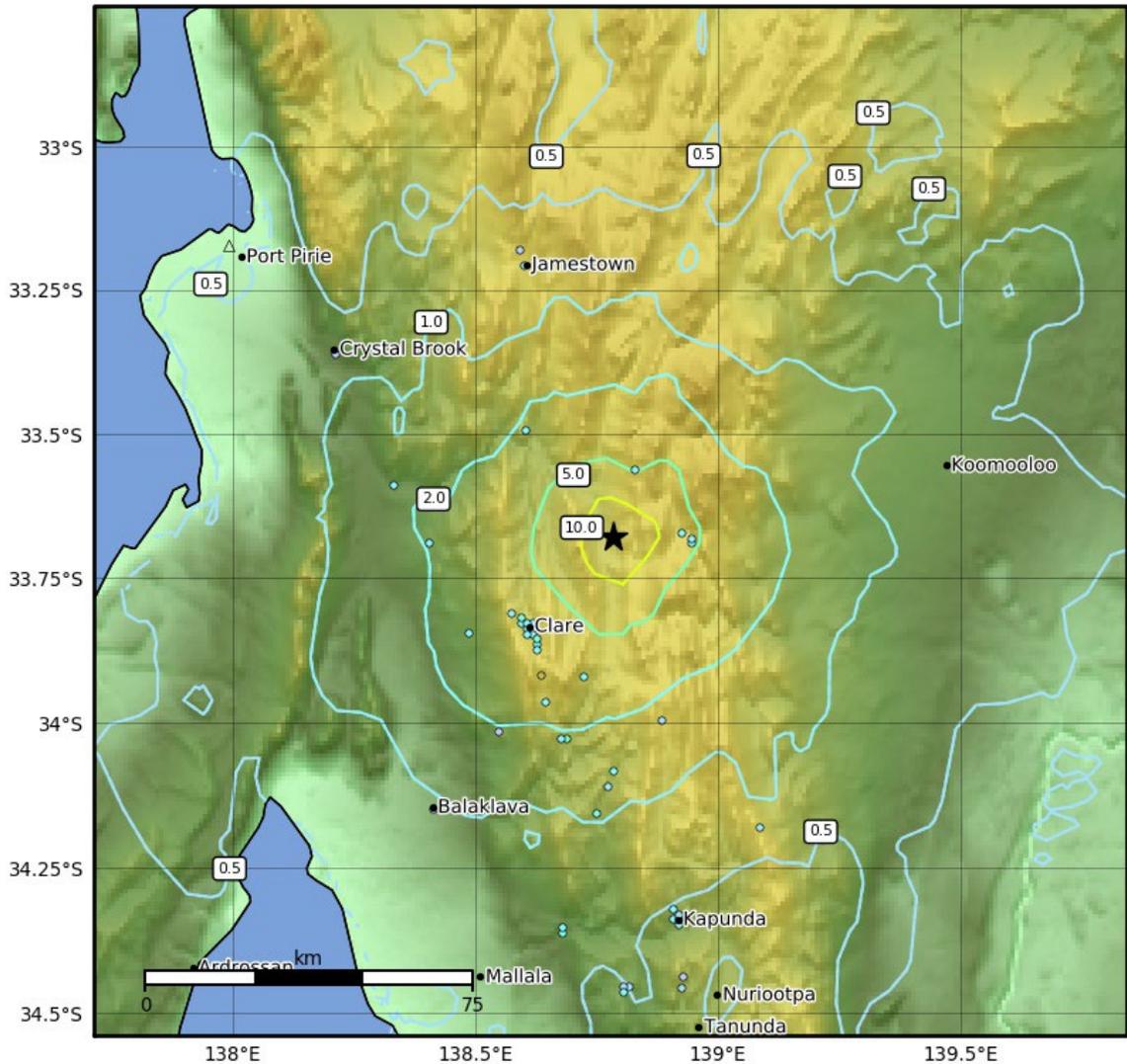


Figure 2. Left: Topographic relief map of the Flinders and Mount Lofty Ranges. Source: Sandiford, 2003. Right: Association of historical seismicity (dots) with topography and faults (black lines) of the Flinders and Mount Lofty Ranges. Source: Celerier et al., 2005.

Peak Ground Acceleration Map
GA ShakeMap: Version 4
14 May 2020 05:53:34 UTC M4.3 S33.68 E138.78 Depth: 14.1km
ID:ga2020jmlaqc

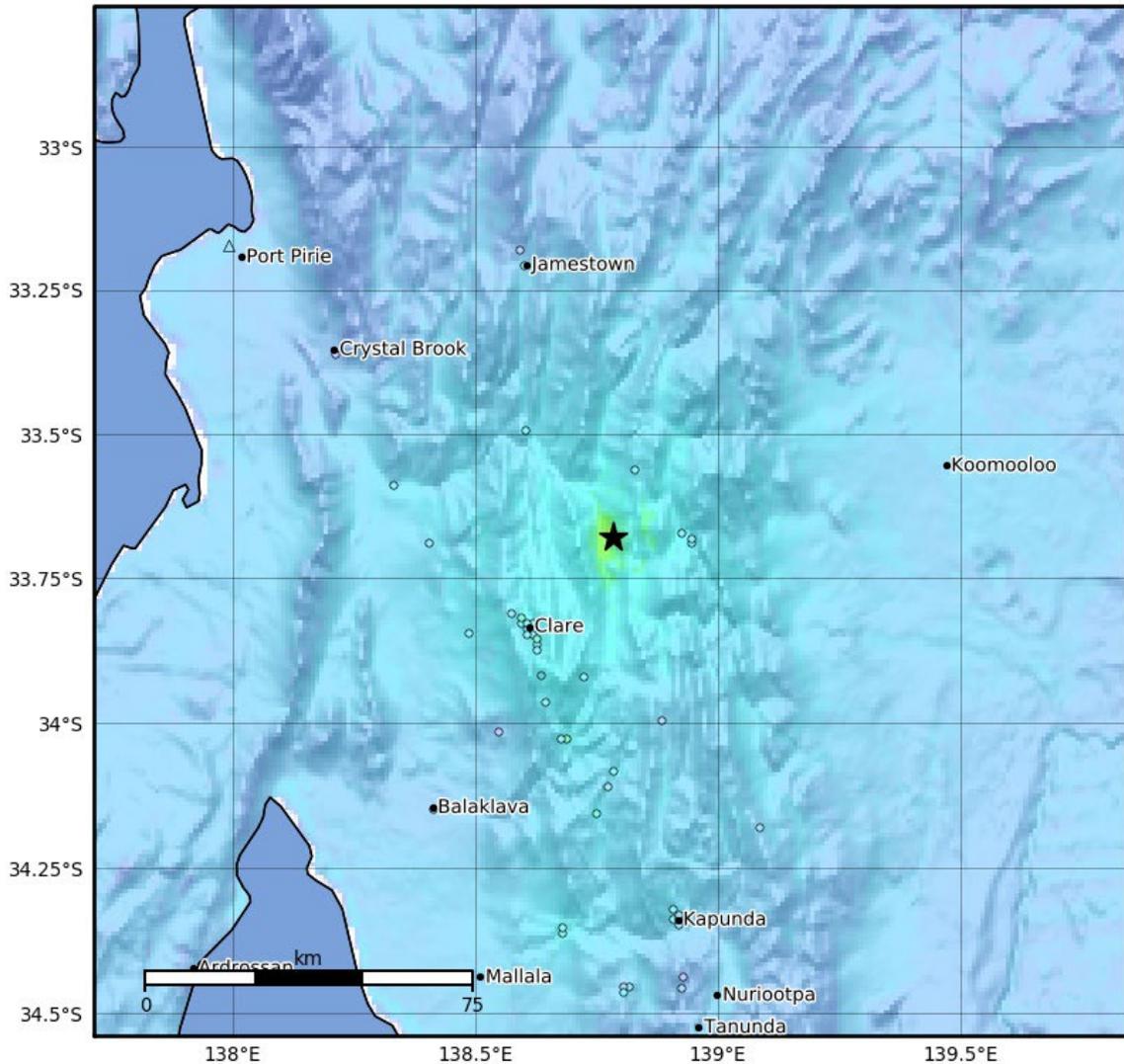


PGA (%)	0.1	0.2	0.5	1	2	5	10	20	50	100	200
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Scale based on Worden et al. (2012) Version 4: Processed 2020-05-14T07:49:18Z
 △ Seismic Instrument ○ Reported Intensity ★ Epicenter

Figure 3. Contours of estimated peak acceleration (in percent g) from the Burra earthquake; the yellow contour represents 10%g. Source: Geoscience Australia, 2020.

Macroseismic Intensity Map
GA ShakeMap: Version 4
14 May 2020 05:53:34 UTC M4.3 S33.68 E138.78 Depth: 14.1km
ID:ga2020jmlaqc



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.05	0.3	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.02	0.13	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012)

Version 4: Processed 2020-05-14T07:49:18Z

△ Seismic Instrument ○ Reported Intensity

★ Epicenter

Figure 4. Estimated MMI intensity from the Burra earthquake; the epicentral intensity is MMI V.
Source: Geoscience Australia, 2020.

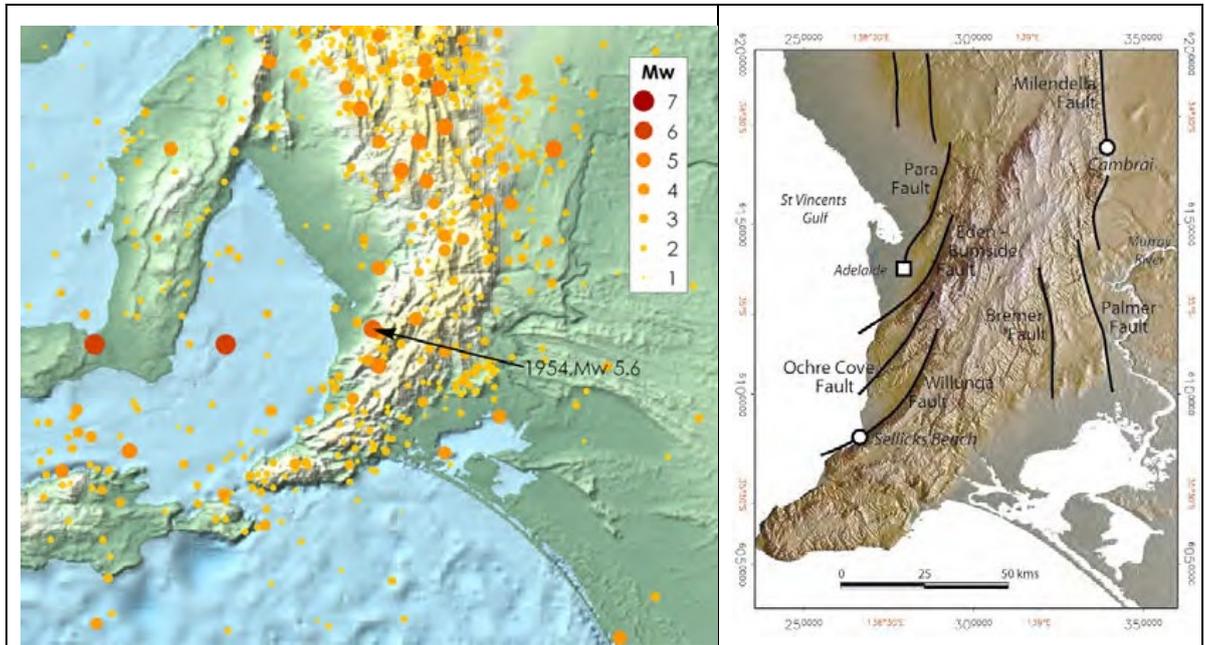


Figure 5. Left: Historical seismicity of the Adelaide region showing the location of the 1954 Adelaide earthquake. Right: Active faults of the Mt Lofty Ranges including the Eden-Burnside fault to the east of Adelaide. Source: Sandiford (2003).

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