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The Mount Barker ML3.7 Earthquake, 5th March 2022

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Abstract

An earthquake of magnitude 3.7 occurred on 5th March 2022 at 2050 UT in the well instrumented Mount Lofty Ranges region. The hypocentre was under Mount Barker at a depth of about 23 km. It was felt across Adelaide and suburbs. Extra instruments were deployed. Fourteen aftershocks were located, mostly with very high accuracy. Two focal mechanisms were produced. It is not clear if the mainshock is related to any major fault in the region. The large number of felt reports in metropolitan Adelaide do not show any areas of major amplification, although small variations can be observed. This earthquake is similar to a previous one in 2010 in terms of location, depth, magnitude and felt response, but different in aftershock activity.

Keywords: aftershocks, amplification, felt report, focal mechanism, depth, magnitude.

1 Introduction

Mount Barker is the largest town in the hills east of Adelaide. An earthquake of magnitude 3.7 occurred on Sunday 6th March, at 7:20am (5th at 2050 UT) and was widely felt without causing any obvious damage. It was the most significant event to occur near Adelaide since a similar event on 16th April 2010 (Love, 2010). The surrounding region is well monitored, however the Seismological Association of Australia Inc (SAA) still installed a few extra seismograph stations in Mount Barker and to the east to improve coverage in that direction. There were large numbers of felt reports to the Geoscience Australia (GA) website, but no area showed high intensities. There was no indication of wide-spread panic. Some aftershocks were felt, but mostly weakly, apart from a late aftershock of magnitude 3.0 on 29th March.

2 Historical seismicity

The first earthquake recorded near Mount Barker was in 1883; a magnitude ML(I) 4.7 event with an epicentre in the vicinity of Mount Barker (McCue, 1980, Everingham, 1982). The historical catalogue lists a few other small felt events before a seismograph network was established in 1964. In 2010 there was an event at approximately the same epicentre, depth and magnitude as this recent one (Love, 2010). Apart from these two events, the seismicity in the surrounding 20 km is quite low compared to further north (the Barossa Valley) and further south-west. Figure 1 shows the seismicity since 2006 when the recording network expanded considerably.

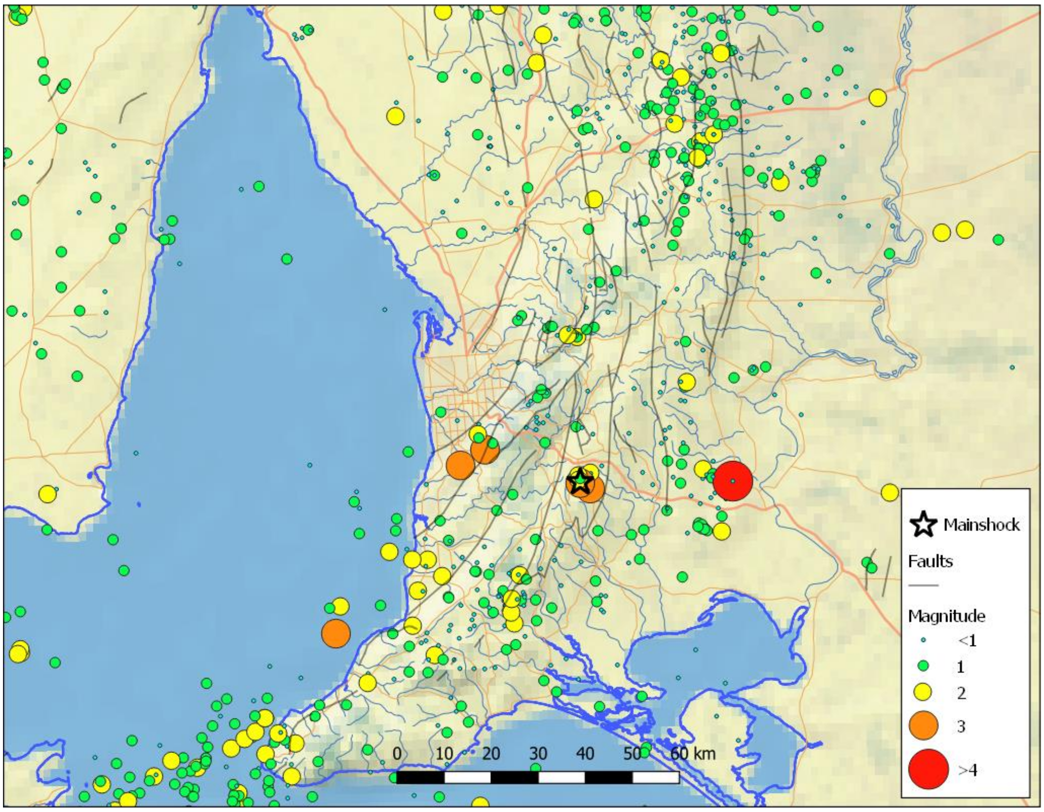

Figure 1. Seismicity and faults of the region since 2006. Black star indicates 5th March 2022 event

3 Mainshock details

3.1 Location

Stations operating at the time of the mainshock are shown in Figure 2. SAA had 14 stations operating within 100 km of the epicentre, GA 2 and Australian National University (ANU) 1. The three portables installed by SAA after the mainshock are also shown in the Figure 2.

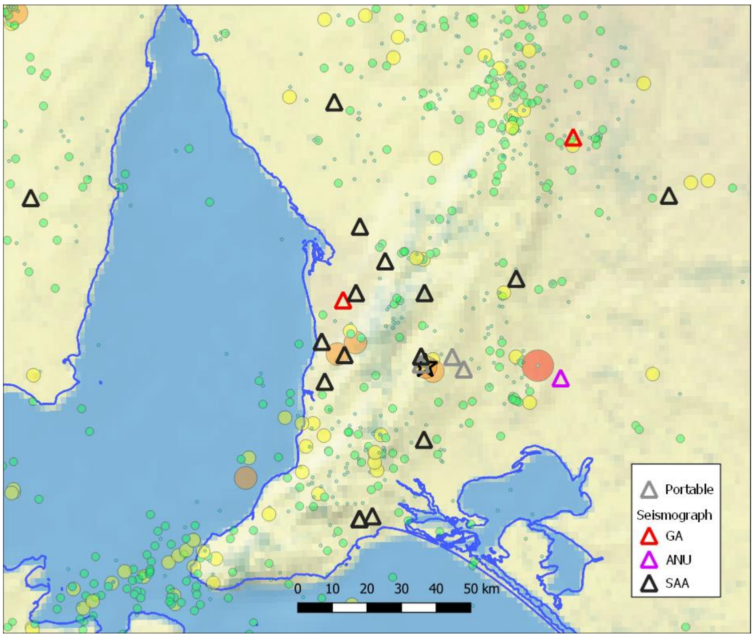

Figure 2 Stations operating at mainshock time, and portables installed.

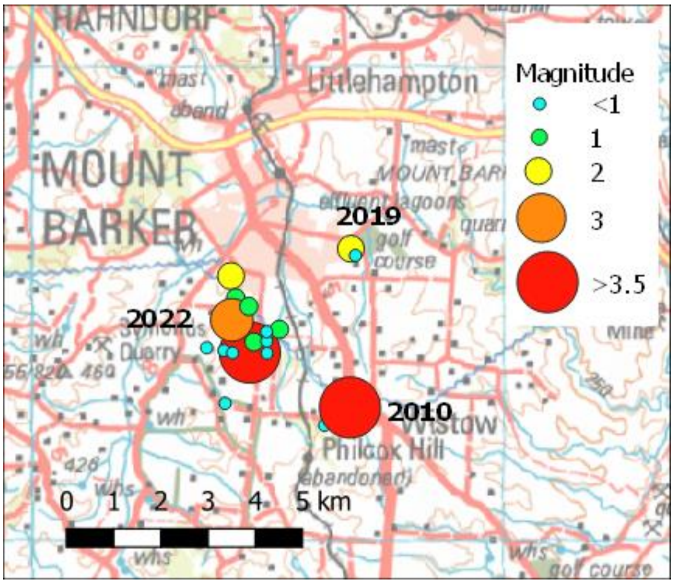

Figure 3 Epicentres of 2010 event, 2 events during 2019, and mainshock and aftershocks of Mar 2022.

The locations of the mainshock and 14 aftershocks are shown in Figure 3. Given the detailed monitoring and clear arrivals, the aftershocks nearly all cluster in a small area less than 2 km apart. Horizontal errors of less than 1 km (1σ) are indicated by the Eqfocus location program. The 2010 event is mapped as less than 3 km to the south-east, although given the difference in station coverage and likely uncertainties, this could be at the same point.

3.2 Depth

Since four of the nearest recorders were driven off-scale by the mainshock (16 bit recorders), the depth of the mainshock was not quite as well constrained as the aftershock depths. The preferred depth of the mainshock, from an average of the best located aftershocks is 23 km. It was found that including more distant stations with refracted rays increased this by a few km. This suggests that the depth of the 2010 event, originally quoted as 26 km is potentially at the same depth, as it used more distant stations. The uncertainty in depth is greater than in the horizontal, and is affected by the velocity model. The SA1A model (White, 1969) being used is a single layer (Vp 6.23km/s, Vs 3.58km/s) with a 38km Moho. Standard deviation of residuals for the events were 0.1 to 0.2 sec. GA quoted the normal depth of 10 km, with their closest station being 28 km away.

3.3 Rupture

The stations PLMR and STR2, at epicentral distances of 22 and 36 km respectively, captured the initial P arrival well. When integrated with no filtering, the STR2 record shows displacements returning to near zero after 3 pulses totalling 0.34 seconds. The PLMR record shows a similar result.

4 Focal mechanisms

First motion focal mechanisms were produced for the mainshock and the largest aftershock. Previously focal mechanisms were produced for the 2010 event and a magnitude 2.2 event (depth 22 km) in 2019. These are all shown in Figure 4.

Four extra stations (portables and one permanent) not running for the mainshock were added to that mechanism, as aftershock first motions were consistently of the same polarity.

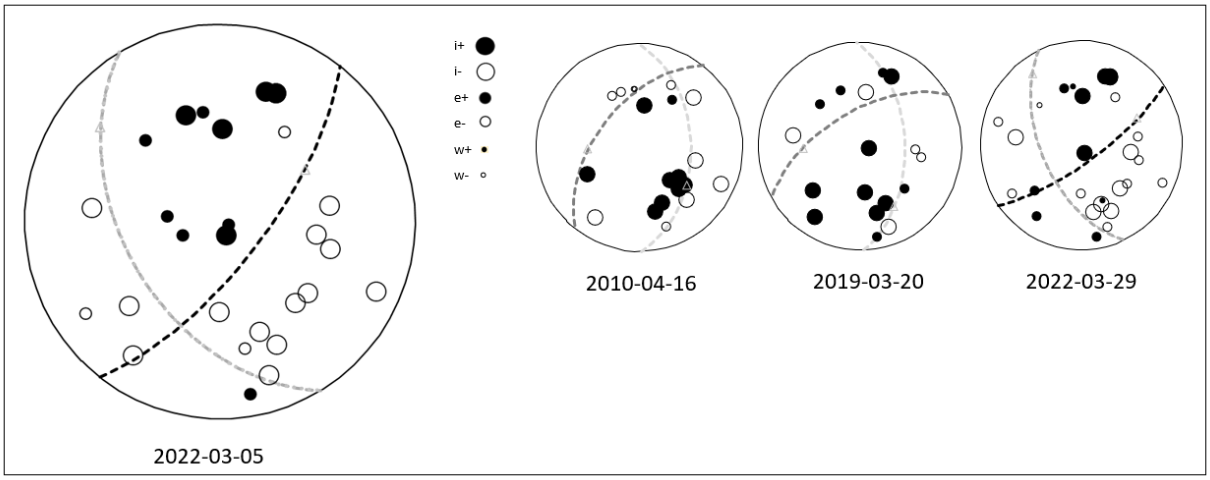

Figure 4. Focal mechanisms for mainshock 2022-03-05 M3.7, 2010-04-16 M3.7, 2019-03-20 M2.2, 2022-03-29 M3.0. Velocity model SA1A. Aftershock polarities shown for four extra stations. Nodal planes shown as dashed curves. Normals to nodal planes shown as small grey triangles.

First motions at close range for deeper events generally produce clearer results than regional or shallow events, regardless of magnitude. Thus these diagrams include a high percentage of i+ and i- values. The mainshock mechanism looks clear and well constrained. The other three events appear relatively sound also. Use of S_V/P amplitudes would improve these still further.

The mainshock and ML(SA) 3.0 aftershock on 29th have similar nodal planes. The 2010 event closely matches the ML(SA) 2.2 2019 event. All four events share similar compression axes, However, the earlier two have quite different nodal planes to the 2022 events. Figure 5 shows the surface projection of all the possible planes as a series of strikes and dips. None of these appear closely related to surrounding faults, although at a depth of 23 km it is not certain.

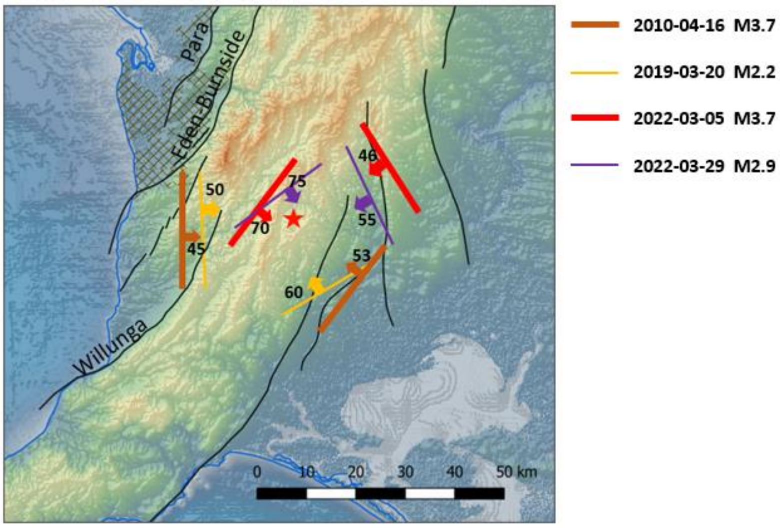

Figure 5. Surface projections of nodal planes of all four focal mechanisms, shown as strikes and dips. Mainshock position shown by red star.

5 Felt reports

5.1 Public response

Comparing the 2022 event with that in 2010 reveals how internet and mobile communications have improved the response to earthquakes. In 2010, the earthquake occurred late on Friday night, and the 000 emergency number was swamped for more than an hour despite no fires, injuries or clear damage. The Primary Industries and Resources South Australia (PIRSA) team was swamped with calls for hours. Both PIRSA and GA websites were saturated with hits, despite not having any information up on the event. Some emergency response organisations reported following Twitter to gather details, not knowing where to get the most reliable information. The PIRSA website did not contain information until Monday morning. In that era it was not easy to quickly swap data for hypocentre calculation. This time reliable information was easily accessed, and the level of concern was significantly less.

5.2 Digital felt reports

The Geoscience Australia website (Allen et al, 2019) has now come of age. Information was up quickly and always accessible. It received over 12,000 felt reports for this event, compared to about 160 for the 2010 event. The USGS "Did you feel it?" site, on which the GA questionnaire is based, registered 67 reports, compared to 742 for the 2010 event. Near the epicentre up to 1 in 25 of the population sent reports from their mobile devices. This is shown in Figure 6, using population data from the 2016 census. Figure 7 shows that a higher proportion of people in country postcodes responded than inner suburbs.

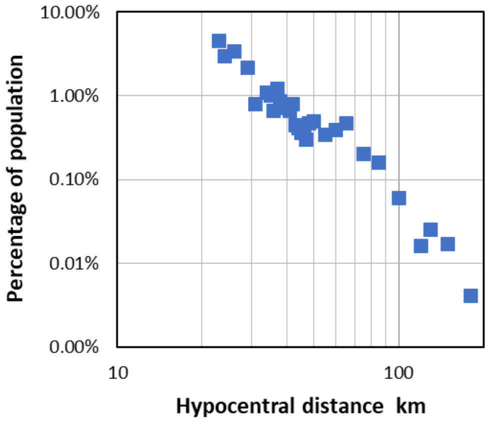

Figure 6. Percentage of people reporting; average of postcodes binned by hypocentral distance

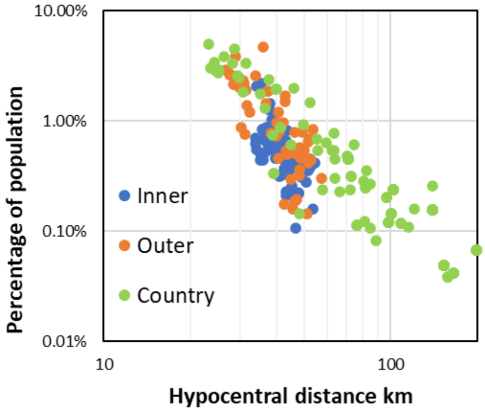

Figure 7. Percentage of people reporting showing postcode categories: inner (50xx) and outer (51xx) suburbs and country.

Modified Mercalli (MM) intensity is normally reported in integer values, with occasional integer ranges listed. The Community Decimal Intensity (CDI) reports result in non-integer values, but as these are still quantised in the GA implementation, averaging of multiple reports is useful to distinguish possible small variations between areas. The GA felt report grid shows very limited intensity variation across the Adelaide suburbs.

In this analysis we first removed a distance attenuation function calculated from a linear regression of the data points:

$5.79 - 1.71 * \log_{10}(hypodist)$

We then used the k-means clustering method. This partitions observations into a specified number of clusters, with each observation belonging to the nearest cluster centroid. The squared observation-to-centroid distances are minimised. We averaged all observations without removing any values considered anomalous. We used 800 clusters in the analysis, then removed all clusters with less than 5 values. The results are displayed in Figure 8, with CDI residual being shown by colour, and number of observations by size. Note from the legend that the variations are *very* small compared to whole intensity units.

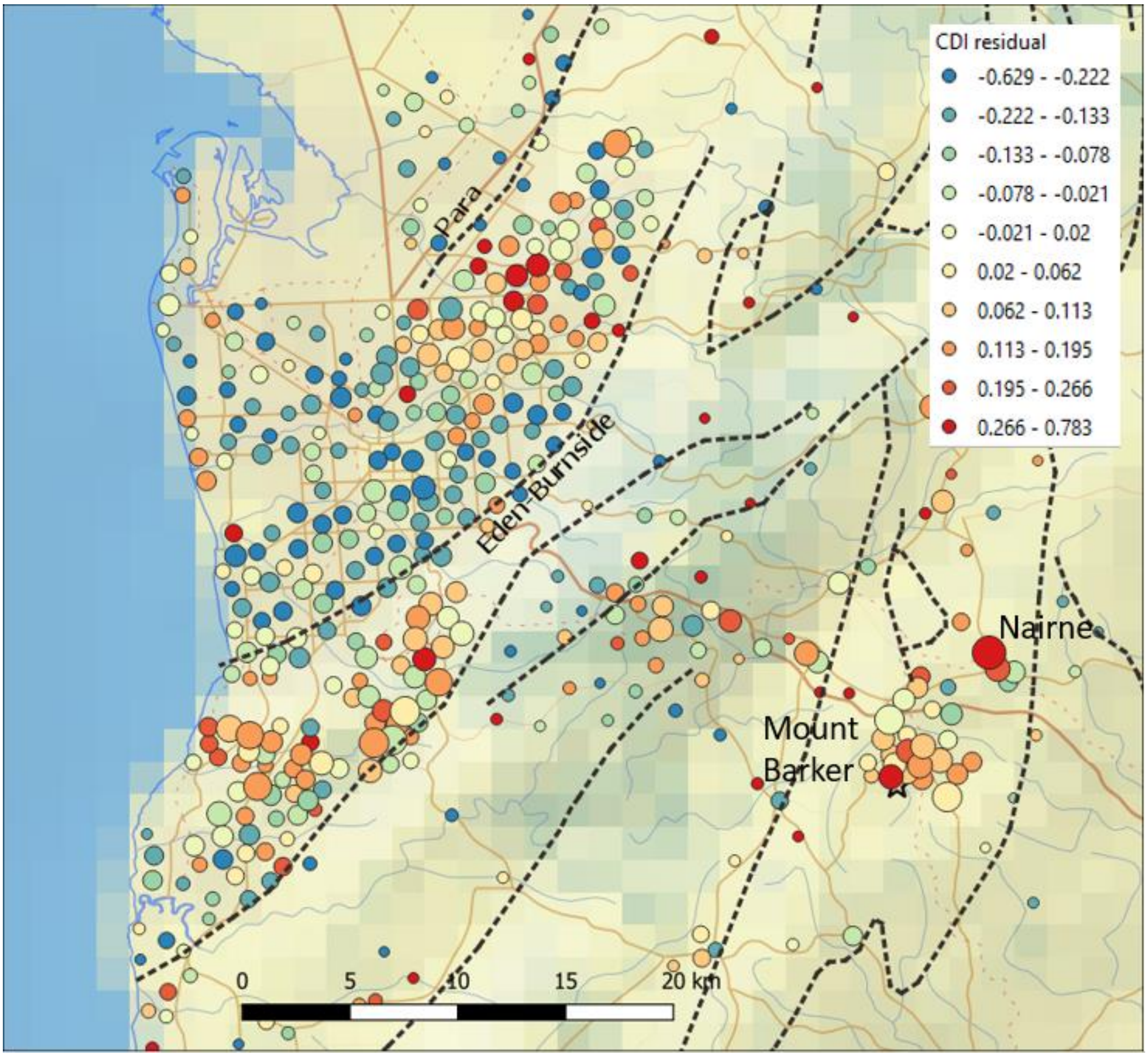

Figure 8. Residual CDI values of clusters, shown by colour. Relative number in cluster shown by size. Eden-Burnside and Para Faults labelled.

Small but consistent increases can be seen on the upthrown sides of both the Para Fault and the Eden-Burnside Fault. The lowest values are along, and to the north-west of the Eden-Burnside Fault, with a slight indication of a similar effect on the Para Fault. A similar effect was found in the 2014 Belair earthquake (Love, 2014) where people along the Eden-Burnside Fault did not feel an event, despite being some of the closest areas. The variation from the north-west side of Nairne to the south-east is notable, and the north (freeway) side of Mount Barker seems to have lower intensity.

These results are for low intensity effects (MM II-IV) from a small earthquake. The relevant frequency range is probably 3 to 10 Hz. Caution should be exercised in extrapolating the results to larger events.

6 Magnitude

Using Waves software by the Seismology Research Centre, displacements were calculated with a 1 to 20 Hz filter, instead of the default 2 to 10 Hz filter. Magnitudes were calculated using the ML(SA) scale (Greenhalgh and Singh, 1986), except that a fixed Wood-Anderson magnification of 2080 was used instead of 2800 varying with frequency. The resulting value was 3.66 +/- 0.29 from 24 stations. No station corrections were applied, and no stations arbitrarily removed. This compares well with the GA value of 3.69 +/- 0.40 from 15 stations.

7 Acknowledgements

I thank Geoscience Australia for providing the felt report information.

8 References

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