Australian Earthquake Engineering Society 2014 Conference, Nov 21-23, Lorne, Vic

# The Belair Earthquake, 6th January 2014, Magnitude 2.6

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## Abstract

A small earthquake, magnitude 2.6 occurred at Belair near Adelaide on 6th January 2014 at 8:24am local time. Due to the improved monitoring around Adelaide, an accurate location was possible, with a well constrained depth of 10km. A reasonable focal mechanism revealed a thrust mechanism. Felt reports received by Geoscience Australia indicated that it was felt up to about 45 km away, but surprisingly there were no reports from along the nearby Eden-Burnside Fault. The hypocentre did not coincide with the Eden-Burnside Fault Zone.

**Keywords:** earthquake, focal mechanism, fault-line.

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## INTRODUCTION

In recent years, the seismograph network around Adelaide has improved substantially. This has enabled the detection of smaller earthquakes, and accurate location of hypocentres. On 6 January 2014 at 8:25 am, a small earthquake occurred close to the city. It was widely, but weakly felt across the suburbs and Adelaide hills region. Using data from DMITRE, Geoscience Australia, and private and school seismographs, resulted in an accurate location and depth, and a reasonable focal mechanism was also possible.

## MAINSHOCK AND OTHER EVENTS

The mainshock occurred at 8:25 am local time. Our location was slightly south of Belair, and approximately 9 km south of the city. There were four stations within 10 km of the epicentre, and 12 stations within 50km. The location had a hypocentral error ($2\sigma$) in the horizontal plane of 1.6 km and 1.6 in depth (Figure 1 and Table 1).

The earthquake was preceded by a magnitude 2.1 event at 2:58 am a few kilometres offshore from Port Noarlunga South. The depth of this event is about 24 km, but being offshore its solution is less accurate. This event was felt by very few people. It could not be termed a foreshock, as it was many fault lengths from the Belair event. These were the two largest events in the Adelaide vicinity in the last two years (Fig. 1), and yet they happened within hours of each other, but a considerable distance (32 km) apart.

Eleven days later, on 16 January 2014, a much smaller earthquake, magnitude 0.7 occurred near Athelstone, 20 km away. Similarly, this event is too far away to be called an aftershock.

It is unclear how many small events (eg less than magnitude 1) occur closer to Adelaide. Monitoring until about 2004 was not able to detect many events in this range. At present very few appear to be occurring near Adelaide.

## FELT REPORTS

Geoscience Australia received 193 emails reporting the Belair event. With small events it is often difficult to assign intensities, due to the rapidity of the earthquake, and the considerable sound recognised, even if the vibration was very small. A few reports were considered to be intensity MM4 on the Modified Mercalli Intensity scale, but most were considered to be only intensity MM2 or 3. The replies are plotted in Figure 2 as a percentage of suburb population, not intensity. Two features are apparent. Firstly, the response from the less populated hills area is much greater than the more heavily populated suburbs on the plains. This is possibly due to higher participation of hills people, but also possibly because of lower attenuation with less unconsolidated sediments overlying bedrock, and quieter surrounds, so that sounds are more noticeable. Secondly, along the Eden–Burnside Fault Zone there are many suburbs that did not report the event. It is unclear why

this is so, but it is possibly a combination of thicker soft sediments northwest of the fault absorbing the high frequencies, and non-transmission of vibrations into the tip of the upthrust block to the southeast of the fault. In a large earthquake with more low-frequency content, thick sediments would be expected to amplify vibrations, but this is not necessarily the case for small earthquakes, which have higher frequency content.

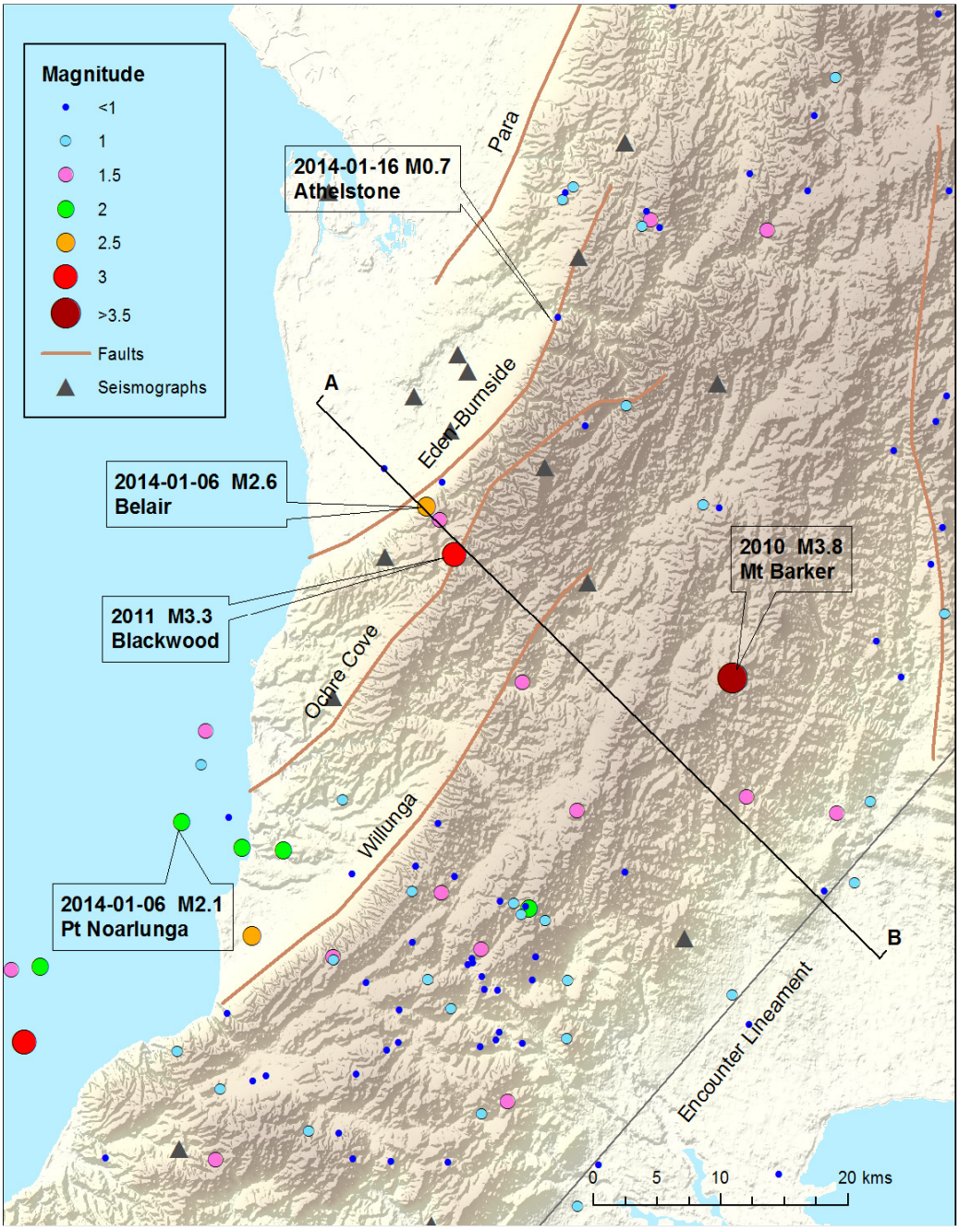


*Figure 1 Earthquake activity near Adelaide for 2007-14, showing significant earthquakes, seismographs and major faults.*

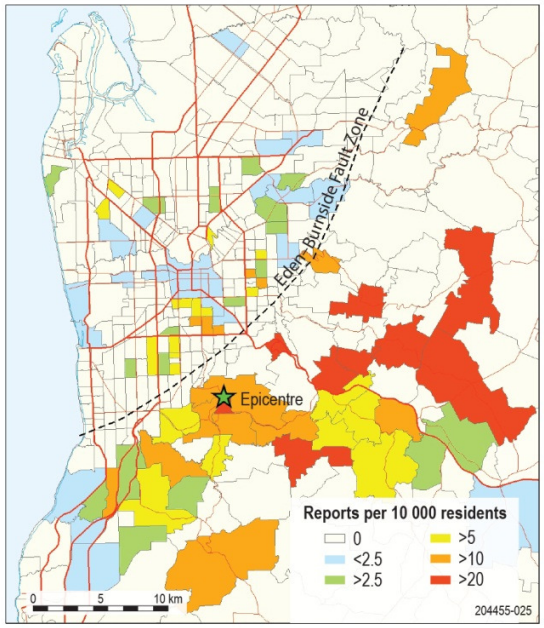


*Figure 2 Felt reports as a percentage of suburb population, showing a gap along the Eden-Burnside Fault Zone near the epicentre.*

## FOCAL MECHANISMS

The focal mechanism for the Belair event is fairly well constrained (Fig. 3a). First arrivals were clear at most stations due to the short distances involved. The mechanism shows near pure thrust. The preferred fault plane (parallel, consistent with Eden–Burnside) is striking 25° and dipping 40° to the ESE. The focal mechanism for the Noarlunga event is not so clear due to poorer distribution (Fig. 3b). It appears to be strike–slip, but still has a similar direction of compression (WNW–ESE). The Athelstone event was recorded on fewer sites. However, it is clear that it is a compressional event, probably similar to the Belair event, but with much less certainty about the strike and dip (Fig. 3c). The addition of a number of private stations (Glanville 2014) has made these focal mechanisms possible.

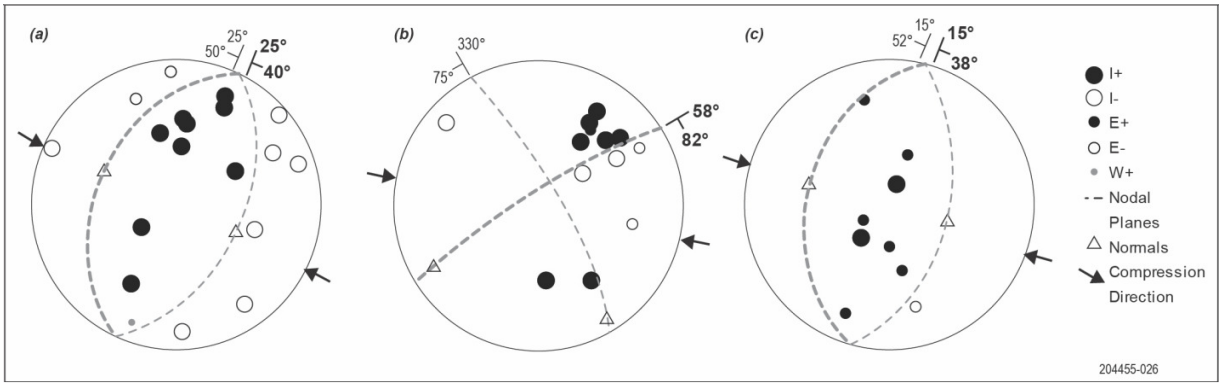


*Figure 3 Focal mechanisms (upper hemisphere) for earthquakes (a) Belair (b) Noarlunga (c) Athelstone. Possible nodal planes are shown as curves along with dip strike details. Preferred fault plane is in bold. Symbol size indicates reliability.*

## ACCURACY OF SOLUTIONS

Principal details of these three events and previous significant events in 2010 (Mt Barker) and 2011 (Blackwood) are given in Table 1. These solutions were all computed using the Eqlocl program, using all phases, including distant ones. Removing phases, to include only those within 100 kms of the epicentre, reduces the standard deviation of the residuals, but also increases the largest gap angle and the error uncertainties. The new private stations nearer Adelaide have

boosted the number of stations within 100 km of the epicentres and improved confidence in the calculated solutions.

| Event | Mt Barker | Blackwood | Noarlunga | Belair | Athelstone |
|---|---|---|---|---|---|
| UT date | 2010-04-16 | 2011-10-18 | 2014-01-05 | 2014-01-05 | 2014-01-16 |
| UT time | 13:57 | 15:52 | 16:08 | 21:55 | 18:24 |
| Magnitude | 3.7 | 3.3 | 2.1 | 2.6 | 0.7 |
| Lat | -35.109 | -35.032 | -35.221 | -35.000 | -34.865 |
| Long | 138.880 | 138.638 | 138.408 | 138.611 | 138.719 |
| Depth | 26.4 | 23.6 | 23.6 | 9.7 | 22.2 |
| E error | 2.2 | 2.7 | 2.4 | 1.6 | 3.0 |
| N error | 1.6 | 1.4 | 1.7 | 1.4 | 1.7 |
| Z error | 1.3 | 1.6 | 2.0 | 1.6 | 2.7 |
| # stations | 30 | 23 | 21 | 29 | 15 |
| stns<100km | 11 | 13 | 16 | 17 | 14 |
| # phases | 48 | 42 | 40 | 57 | 30 |
| SD resid. | 0.45 | 0.42 | 0.36 | 0.44 | 0.32 |
| gap angle | 67 | 110 | 134 | 68 | 106 |

*Table 1 showing solutions and errors for the three events in 2014, and previous significant events in 2010 (Mt Barker) and 2011 (Blackwood).*

## DISCUSSION

Besides the 2014 Belair event, there have been two other recent felt events in the Adelaide Hills region. The Mount Barker event of 2010 (magnitude 3.8) was well located (Love 2010), as was the 2011 Blackwood event (magnitude 3.3), which was not the subject of a specific report. Both of these were much more widely and strongly felt than the Belair event, and received considerable media attention.

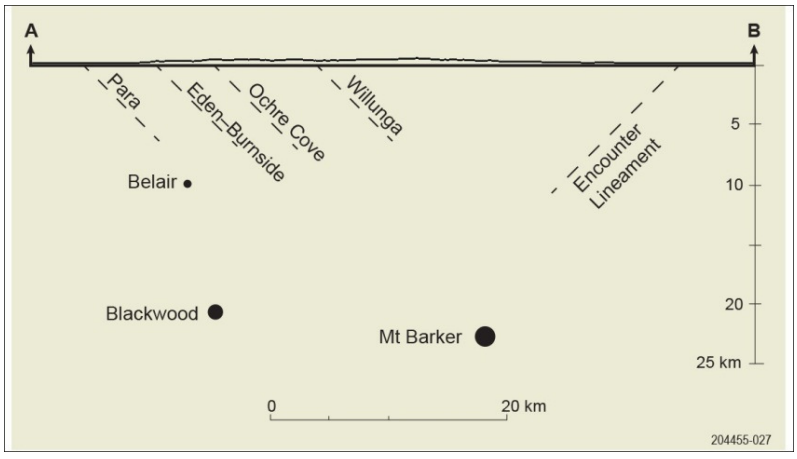


*Figure 4 Cross section A-B from figure 1, showing depths of Mt Barker, Blackwood and Belair earthquakes and estimated position of faults.*

Figure 4 shows the depth of the Belair, Blackwood and Mount Barker (Love, 2010) earthquakes with respect to the major faults. Currently it is assumed that the major faults to the west of the Mount Lofty Ranges (Para, Eden–Burnside, Ochre Cove and Willunga) are all reverse faults.

There are rare outcrops of fault zones that dip under the ranges, consistent with compressional stress. Evidence from gravity modelling suggests a range of dips. Figure 4 shows dips of 45°. It is clear that the Belair event is too deep to be on the Eden–Burnside Fault, but could conceivably be on the Para Fault. The Blackwood event probably is not on any of these western faults, and the Mount Barker event could be on a number of the faults. To date we still have only a modest number of accurately located events in the region. There is no clear indication yet of any preferred planes indicating active faults. It may be that these earthquakes scatter across a volume, and not on any particular fault plane (Love, 2013).

## REFERENCES

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