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Recent results from the Adelaide Seismograph Network

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ABSTRACT: The improved monitoring network around Adelaide is resulting in new information. Many more hypocentres are being located. Two small earthquakes this year have had sufficient clear arrivals to estimate focal mechanisms. These and other recent ones show near horizontal stress in a direction close to east-west. Earthquake depths are from near surface to about 25 km, with a slight indication that larger events occur deeper. There are insufficient events to produce a clear Gutenberg – Richter relation, but indications are that the b value is near 0.8. While expected errors have decreased significantly, depth errors in smaller or shallower events can still be significant. A recent timing error on a number of instruments was not easy to detect, showing that constant vigilance is required. No clear planes of activity can be seen so far.

1 INTRODUCTION

The network near Adelaide increased significantly from 2006. Firstly, a sensitive network of seven stations improved detectability of small events, and secondly, a number of lower quality private stations has improved the data quality. This has resulted in the annual number of events located within 100 km of Adelaide increasing from about 10 prior to 2006 to about 70 in 2014 (Wallace and Love 2014). Figure 1 shows activity from 2007 to the present. Further analysis concentrates on the polygonal area. This has the densest distribution of seismographs.

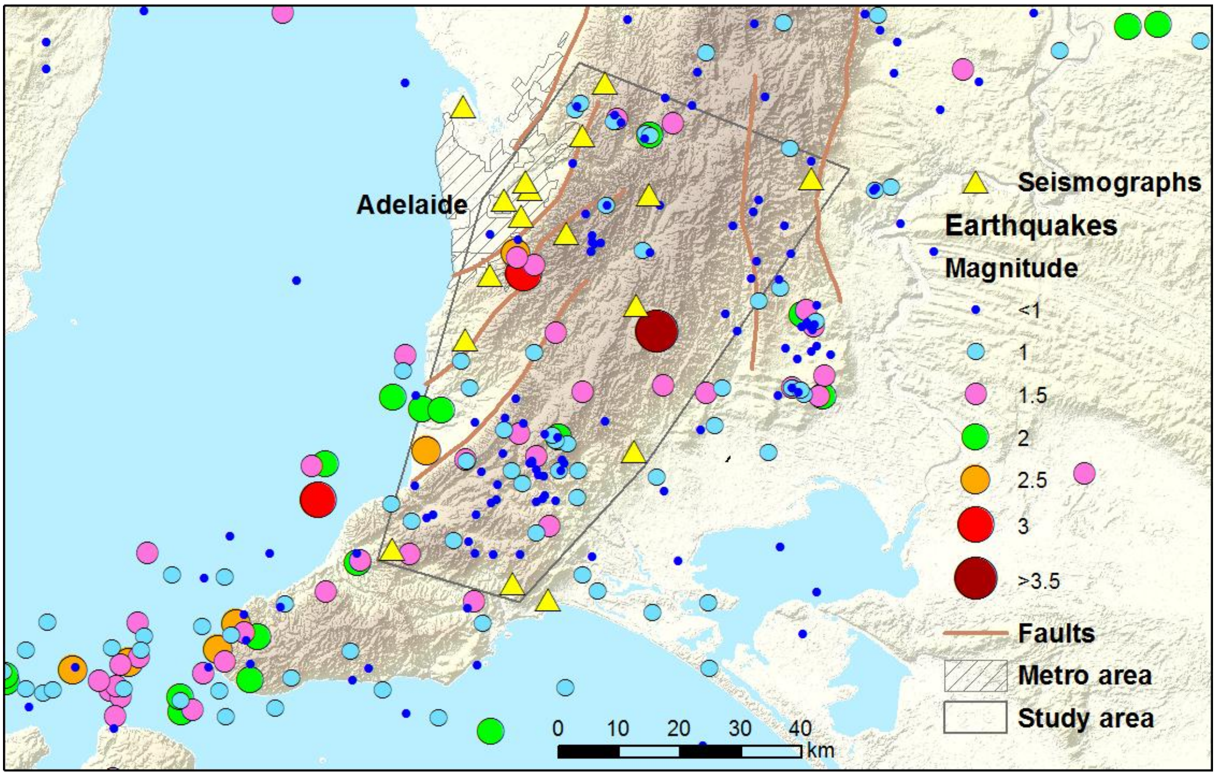

Figure 1 showing earthquakes since 2007, and study area.

2 FOCAL MECHANISMS

Two small earthquakes this year resulted in focal mechanisms. The earthquakes occurred less than a week apart, separated by about 30 km. The first was a magnitude 1.7 event 12 km deep near Belair on 2015-03-24, followed by a magnitude 2.3 event 20 km deep near Kersbrook on 2015-03-30. The focal mechanisms are shown in figure 2. They both reveal mainly reverse faulting with compression between east-west and south-east, north-west. This follows three focal mechanisms produced in 2014, which also happened in a short time frame, but many kilometres apart (Love 2014).

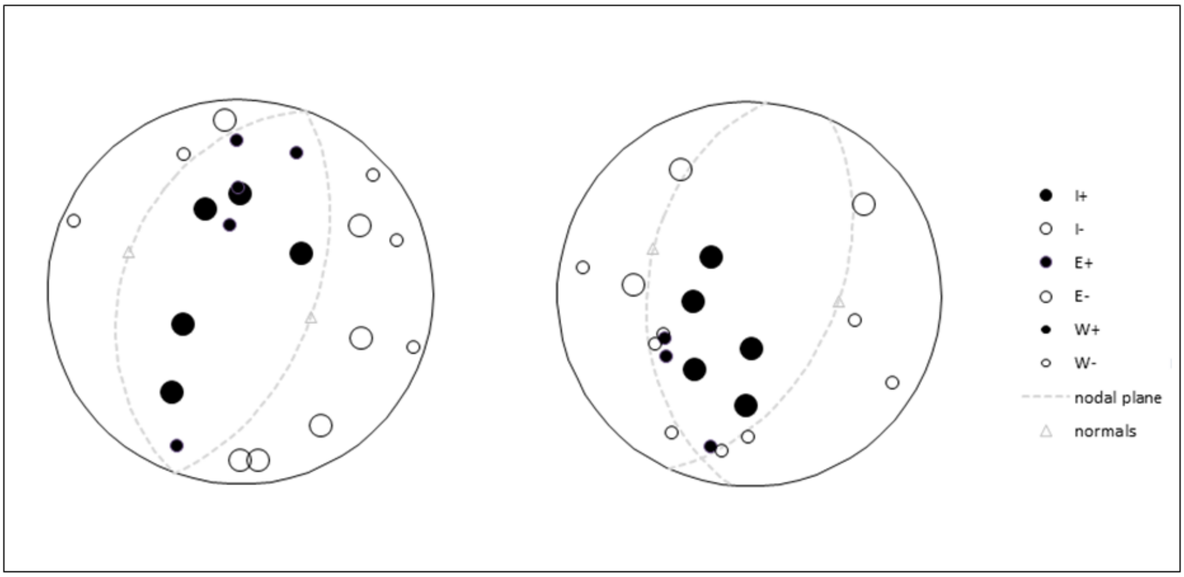

Figure 2 Focal mechanisms for 2015-03-24 M2.3 (left) and 2015-03-30 M1.7 (right).

3 DEPTH DISTRIBUTION

Hypocentres occur from near surface to 26 km. Figure 3 shows that they are well spread over the range with most occurring in the 10 to 20 km range. To date, only one event has been recorded deeper than 25 km, this being the largest event. Depth errors are likely to be greater for events in the top 10 km, since in many cases there will not be a station above the event. However, this is unlikely to change the shape of the depth distribution plot. Moho is estimated to be 35 to 40 km.

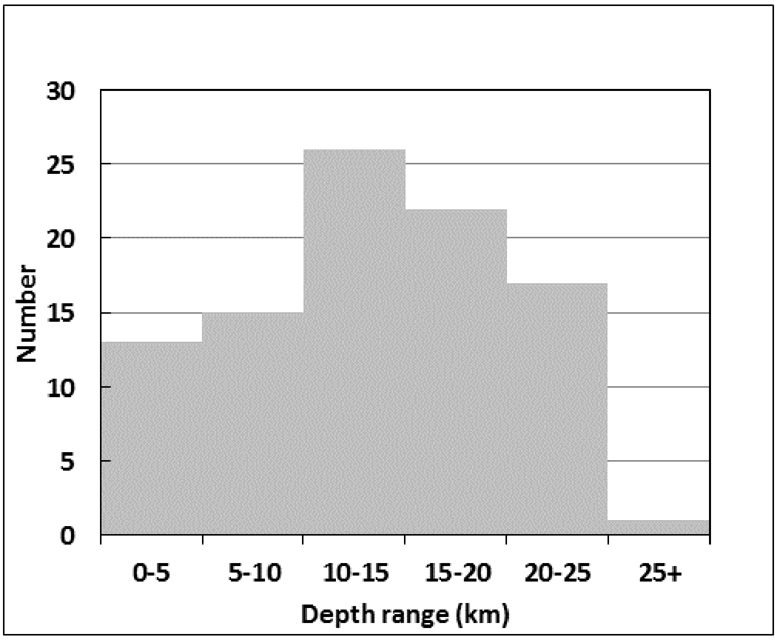

Figure 3 showing depth distribution of hypocentres in the study area.

4 GUTENBERG – RICHTER RELATION

There are insufficient hypocentres to produce a robust and reliable b value plot at present. Figure 4 shows all the data (74 points, declustered, in the study area) with a b value of 0.8 for comparison. This is an approximate fit for low magnitude events. Previous analyses have used a b value of 1.0 and 0.99 for the whole Adelaide Fold Belt (Gaull et al 1990, Burbidge 2010), but lower values when the south end of the Fold Belt is considered separately (Love, 1996)

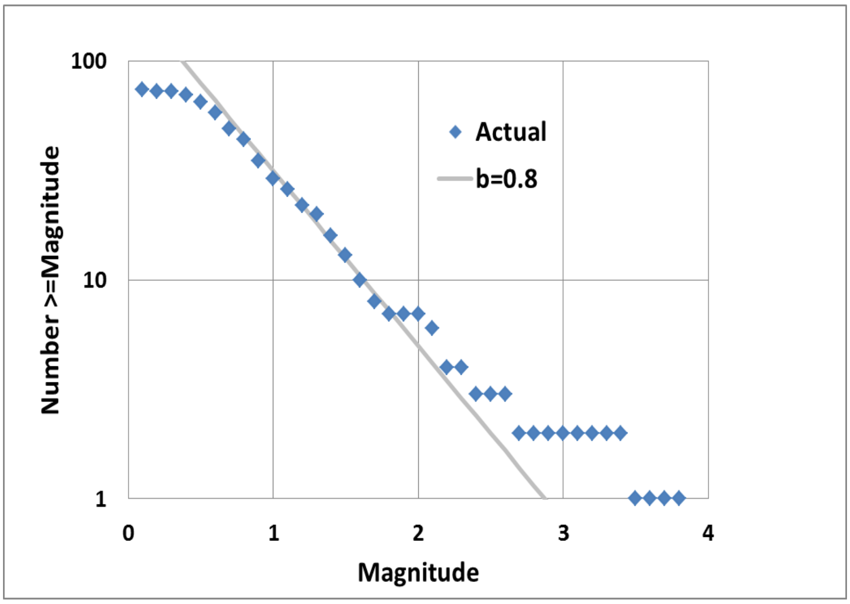

Figure 4 showing cumulative distribution and a b value of 0.8 for comparison.

Figure 5 shows the variation due to depth. There is an indication that the b value is lower at depth, but there are insufficient data to say how much this variation with depth is likely to be. As above, this is still only for the low magnitude event range.

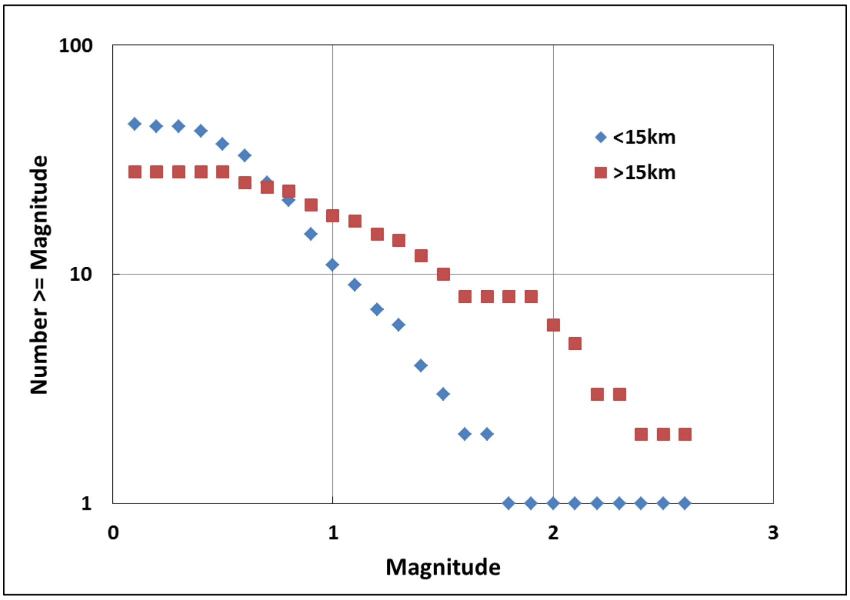

Figure 5 showing cumulative distribution for different depth ranges.

5 EVENT SEQUENCES

Within the study area, there were cases where a number of events appeared to be occurring in the same place over a relatively short time. Ten such event sequences were identified, ranging from 2 to 6 events. Of these sequences, five followed a standard pattern with the largest occurring at or near the beginning, and two where the largest event occurred last. These occur in both shallow and deep situations. The first one was noticed in 2010 about the time of the magnitude 3.8 Mt Barker event (Kuitpo events in Love 2010). It was then considered unusual for repeated events to occur at depth (20 - 24 km). It is not clear whether these places will be the source of future events over decades, or whether activity will continually move.

6 DATA ACCURACY

Event sequences give an opportunity to check location accuracy. It is assumed in each sequence that the events come from very close (<100 m) to the same point. In these sequences, events were separately located, and the standard, single layer SA1A model (38 km deep) was used throughout. Brief results are given in Table 6. It shows that vertical errors continue to dominate, particularly when events are shallow or small. When events become deeper and above magnitude 1.5 then depth estimates become very reliable, with velocity model uncertainty becoming one of the key factors. With the denser concentration of seismographs, it is not difficult to determine if one station is one second or more in error. With wide spacing, a one second error can easily be overlooked. Earlier this year, a firmware fault on a batch of GPS receivers resulted in six recorders in the network having a one second error. This error was not immediately picked up. Until it was detected, it just increased the standard deviation of residuals. It shows that constant vigilance is required to maintain high data quality.

Sequence number	Number of events	Depths	Depth variation	East-west variation	North-south variation
1	2	2.0-2.2	0.2	0.2	0.6
2	4	19.4-20.2	0.8	1.1	1.1
3	4	19.8-21.5	1.7	0.9	0.9
4	4	13.0-15.3	2.3	1.4	1.3
5	3	0.7-5.3	4.6	2.9	0.7
6	6	0.1-5.8	5.7	2.2	3.7
7	5	20.4-24.9	4.5	3.6	1.3
8	4	0.1-7.7	7.6	1.4	2.0
9	2	9.7-10.7	1.0	0.2	0.8
10	2	21.0-21.4	0.4	0.5	0.5

Table 6 showing spatial variation in km between events at the same location.

7 CONCLUSION

The Adelaide seismograph network is producing not only more hypocentres, but also information relating to stress, depth distribution and hazard. This is from an area that previously produced very little. Further review of location accuracy is still required for studies to see more clearly if any active planes exist, but current indications are that the low level activity shows no correlation with major faults. Future developments should include computation of a better velocity model.

REFERENCES:

Wallace A. and Love D. 2014. Improved earthquake monitoring around Adelaide. *Proceedings of the Australian Earthquake Engineering Society 2014 Conference*. *Australian Earthquake Engineering Society, Lorne, Vic.*

Love D. 2014. The Belair earthquake, 6th January 2014, Magnitude 2.6. *Proceedings of the Australian Earthquake Engineering Society 2014 Conference*. *Australian Earthquake Engineering Society, Lorne, Vic.*

Love D. 2010. The Mount Barker earthquake, 16th April 2010 Magnitude 3.7. *Proceedings of the Australian Earthquake Engineering Society 2010 Conference*. *Australian Earthquake Engineering Society, Perth, WA.*

Love D. 1996. Seismic Hazard and microzonation of the Adelaide metropolitan area. *Report book 96/27, Department of Mines and Energy, South Australia.*

Gaull B.A., Michael-Leiba M.O. and Rynn J.M.W 1990. Probabilistic earthquake risk maps of Australia. *Australian Journal of Earth Sciences, vol 37 pp169-187.*

Burbidge D.R. (ed.) 2012. The 2012 Australian Earthquake Hazard Map. Probabilistic earthquake risk maps of Australia. *Record 2012/71. Geoscience Australia, Canberra.*