The Mount Barker Earthquake - 16th April 2010 Magnitude 3.7

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Introduction

The Mt Barker earthquake, magnitude 3.7, while only small, was the largest shaking that has occurred in the Adelaide CBD since the 1954 earthquake. In the quiet of night at 11:27pm, it was widely felt, but did little or no significant damage. In a city that experiences few problems from cyclones, storms and floods the public response was significant. There were large numbers of calls to emergency services, despite no injuries or fires. The new Adelaide seismograph network performed well. Early reviewed hypocentre calculations by PIRSA suggested a deep event, with the final solution being 26 km. Aftershock instruments were deployed, but no aftershocks were recorded.

Immediate response

The earthquake occurred at 11:27pm local time, Friday night. The seismograph network delivered the first automatic epicentre and magnitude by SMS two minutes after the first waves arrived. The author was fast asleep, but was awakened by the SMS and another family member who felt it at 11:29pm. Two further SMSs were received a little later. All automatic locations were within 10km of the final epicentre, and magnitudes in the range 3.7 to 3.9. Data were downloaded and the epicentre and magnitude checked. Contact was then made with other seismologists, particularly Geoscience Australia (GA), before contacting Police Communications at 11:49pm to give an epicentre, approximate magnitude and an overview of the likely damage scenario. Due to the good spacing of seismographs, even at this early stage, the possibility of a deep hypocentre, hence no damage, was emerging.

The public response to the event was considerable. The 000 emergency call service received continuous calls for an hour, despite no injuries, fires or significant damage. Alison Wallace, the other member of the Primary Industries and Resources (PIRSA) earthquake team handled continuous phone calls until about 3:15am. The local office of ABC radio was reopened to broadcast live in response to the event. The various tasks, namely earthquake location, earthquake magnitude, attending to calls from the public, media interviews, and notifying management and emergencies services were mostly handled by this two person team. The PIRSA Communications unit was available to take over media communications if the situation became more hectic.

Some management of emergency response organisations reported that they followed Twitter to gather details. It was not clear to them which websites would provide the most reliable information, particularly soon after the event. Both PIRSA and GA websites were saturated with hits, but neither had any information on the event at the time. PIRSA first put up information after the weekend. The USGS Did You Feel It website processed about 400 replies in the first hour, and produced the first reviewed epicentre at about 1:15am SA time. This epicentre was about 80km to the southeast of Mt Barker. It was revised a further hour later to an epicentre close to our final estimate.

One difficult aspect of the earthquake location and magnitude determination is integration of data from more than one agency, so that the best available results can be quickly distributed. As the number of stations increases, the location part appears to become easier, but the potential embarrassment of other organisations publicising different magnitudes is still an issue.

The following day (Saturday), a three man team installed three recorders in the epicentral area, aiming to improve the coverage if aftershocks occurred. PIRSA Communications arranged for all TV interviews and other footage to occur while the first aftershock equipment was being installed. This resulted in good coverage with minimal disruption to busy personnel.

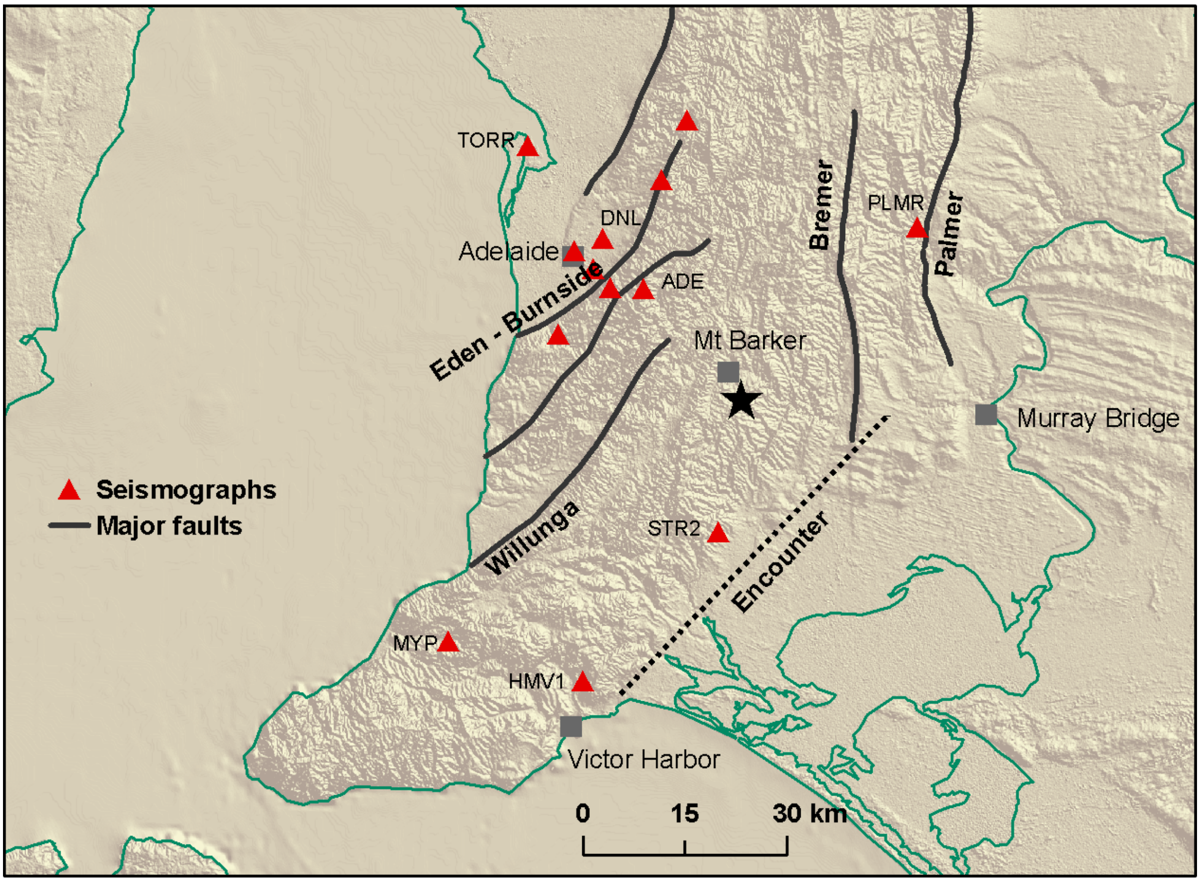

Figure 1 *showing the epicentre location, seismographs, major fault locations and the Encounter Lineament.*

The new Adelaide network consists of a number of Echo recorders with Guralp sensors continuously transmitting to a central computer, running at the PIRSA Glenside office, which uses eqSuite software to calculate the epicentre and magnitude of larger events. Software and most hardware was built and supplied by Environmental Systems and Services

(ES&S), Victoria. Data are delivered in one minute files from each station. The data are filtered, and a trigger algorithm applied. When there are five triggers in a short time window, an epicentre and magnitude are calculated. If extra triggers arrive, another version is calculated less than 2 minutes later.

Source parameters

The best calculated location for the earthquake was at lat -35.109°, long 138.880°, depth 26.4km, with uncertainties of about 2km (0.02°)or less in each direction. The origin time was 2010-04-16 13:57:22.94 +/- 0.22 sec UTC. Standard deviation of phase residuals was 0.45 sec. The monitoring network surrounds the epicentre, having 3 stations within 26 km of the epicentre, and 11 stations within 100km, with a largest gap of 156°. This has resulted in a highly reliable and accurate solution. A total of 48 phases from 30 stations were used in the hypocentre location (figure 1).

The velocity model being used, by contrast, is a very basic single layer model (SA1A), which is used for all locations in the state.

Individual station magnitudes for the PIRSA network ranged from 3.3 to 4.2 (eight stations) with an average of 3.7. The GA network provided 13 station magnitudes from 3.5 to 4.2 with an average of 3.7, and the ES&S network provided 4 station magnitudes from 3.5 to 4.2 with an average of 3.7. This level of agreement is a little unusual!

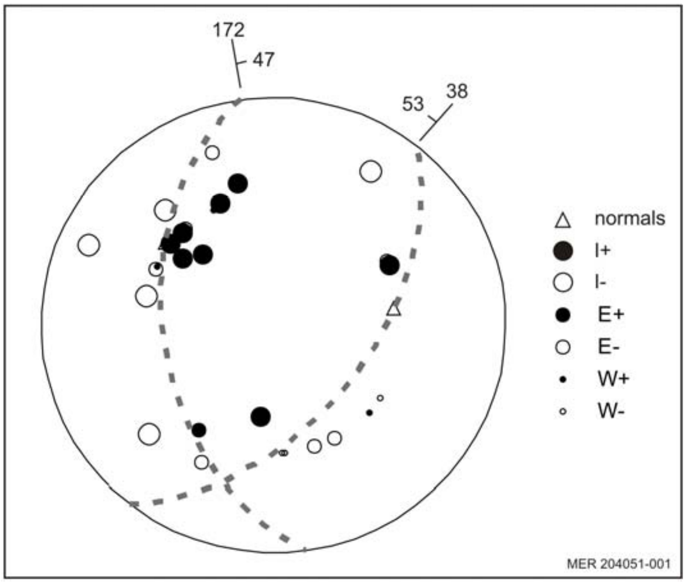

Figure 2 *Focal mechanism (upper hemisphere), with symbol size indicating quality of the first motion polarity. Fault symbols indicate the possible causal faults.*

A focal mechanism (upper hemisphere) was produced from first motions (figure 2), showing a strong compressional component in a nearly east-west direction. 27 of the available records were assigned a first motion polarity, although 6 of these were very poor and were given a W rating and a very small symbol. 13 records were for direct (not refracted) arrivals, which mainly gave clear first motions. The nodal planes are:
Strike 38° dipping 53° (north-west)
Strike 172°dipping 47°(east)

Only 1 station near the epicentre gave a clearly discordant polarity.

At a depth of 26km, it is mainly speculation as to whether the hypocentre lies on an existing known fault. The 38° striking plane is roughly parallel to the Eden-Burnside and Willunga Faults on the west side of the Mount Lofty Ranges, but dipping in the opposite direction (east). The 172° striking plane is roughly parallel to the Palmer Fault to the east, but again dipping in the opposite direction (west). The Bremer fault is considered to be a thrust fault, dipping east. The smaller events that occurred in the region just before and since (see figure 6, Kuitpo events), line up in a roughly 40-220° direction. These events have mostly been of a similar depth. This direction is roughly parallel to the Encounter Lineament, a less clearly defined feature to the south, along the edge of the ranges near Victor Harbor. Given that the rupture area of this event would be less than one square kilometre, deviation from the plane of any fault feature is easily possible.

This is the most southerly focal mechanism in the Mount Lofty Flinders Ranges Zone. Seismograph station spacing was sufficiently close to have the possibility of producing a mechanism. It will however require more stations in the region to acquire more or better mechanisms.

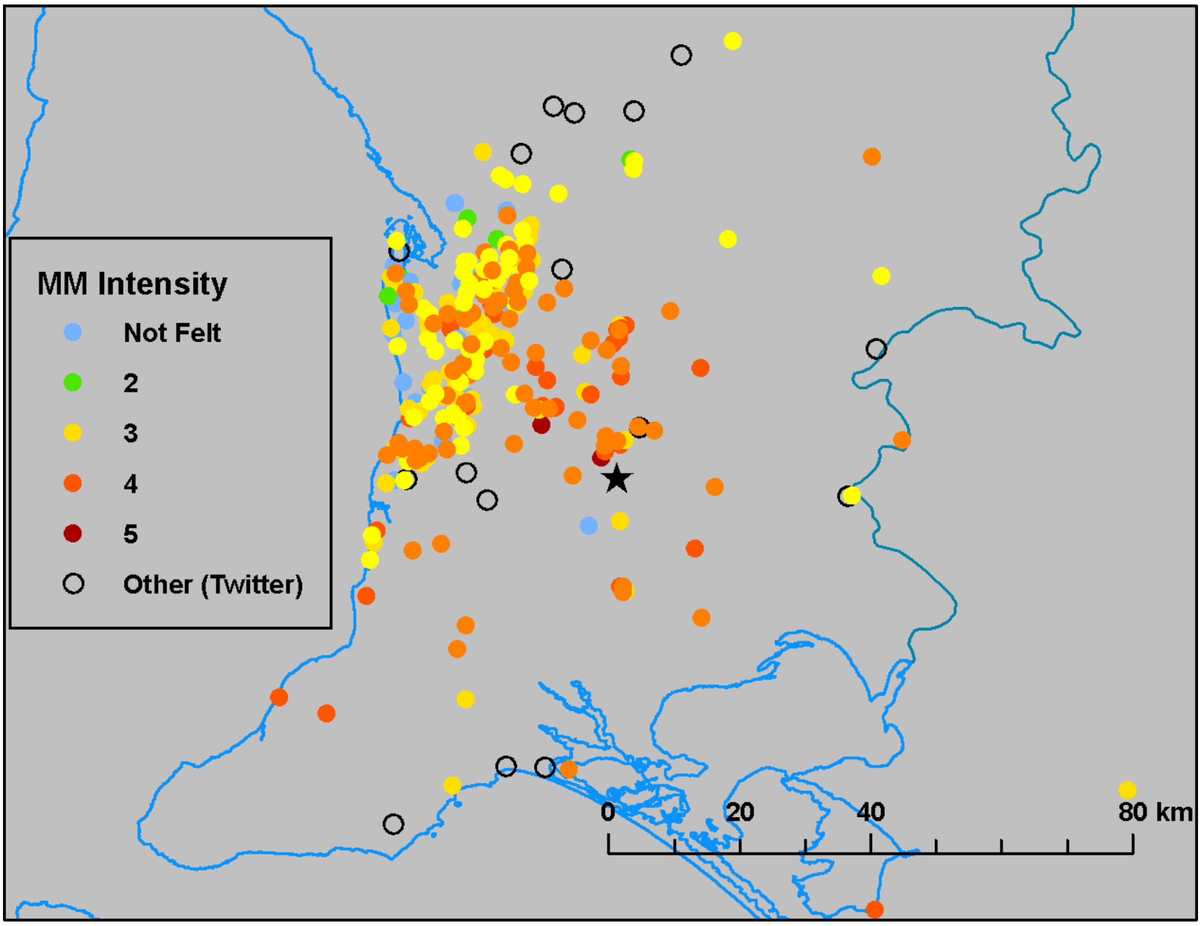

Figure 3 *Intensity information from PIRSA, GA, ES&S with a few Twitter sites included.*

Intensity and ground motion information

The US Geological Survey (USGS) received about 700 replies on its 'Did You Feel It' website. Unfortunately these are not grouped into postcode, but into 6 'city' groups.

PIRSA distributed questionnaires via the department and the State Emergency Service and received 115 replies. Unfortunately these did not have a good geographical spread, and most are concentrated in the metropolitan area. GA received about 160 replies on their website, which also had a similar distribution. Over 35 replies were also supplied by ES&S. Most of these have been included in figure 3.

The combined number of PIRSA, GA and ES&S replies is considerably less than received by the established US website, which also gives near immediate feedback. This certainly demonstrates the need for a similar website to be operating and advertised within Australia.

There is no indication from replies within the Adelaide metro area of particular pockets of amplification, however the density is insufficient to clearly demonstrate any.

Figure 4 shows intensity against hypocentral distance for various parts of the data set. The 6 averaged points of the USGS are the lowest, and these are the closest to the Gaull (1990) attenuation function for SE Australia. Individual points of the PIRSA questionnaires are shown. These were categorised in some cases to half intensity units. Median lines are shown for the PIRSA and GA reports. The median line for the GA reports is slightly higher than the PIRSA median line, and both are significantly higher than the USGS values for intensities higher than 3.

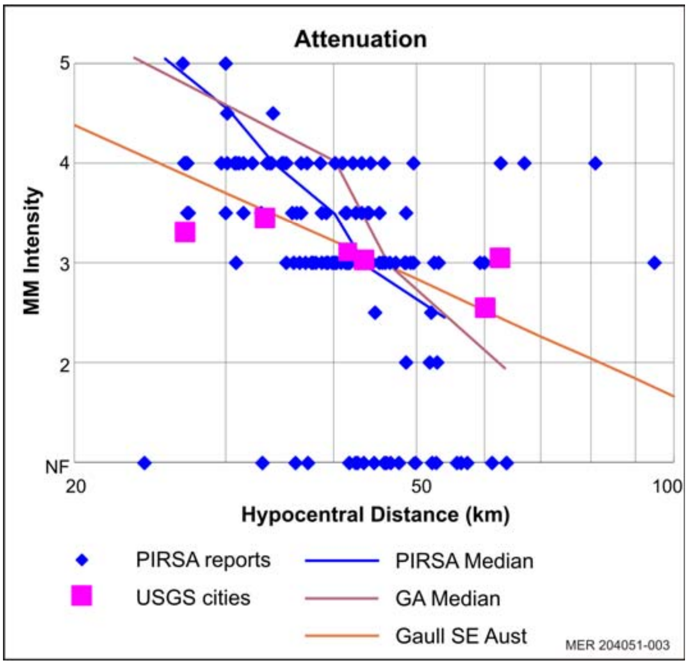

Figure 4 *showing Intensity vs hypocentral distance. Individual reports from PIRSA and 'city' reports from UGSG are symbols. Gaull (1990) attenuation for SE Australia, median values of PIRSA and GA reports are shown by lines.*

Figure 5 shows peak ground velocities for some close seismographs in the PIRSA network. Station DNL is on firm sediments slightly east of the city, and TORR is on soft sediments on Torrens Island NE of the city. The other sites are all on outcropping rock. Each site has three points representing N-S, E-W and vertical directions. The vertical was usually the lowest value. The Atkinson (2007) conversion from PGV to MM was used for the values shown on the right hand axis of figure 5.

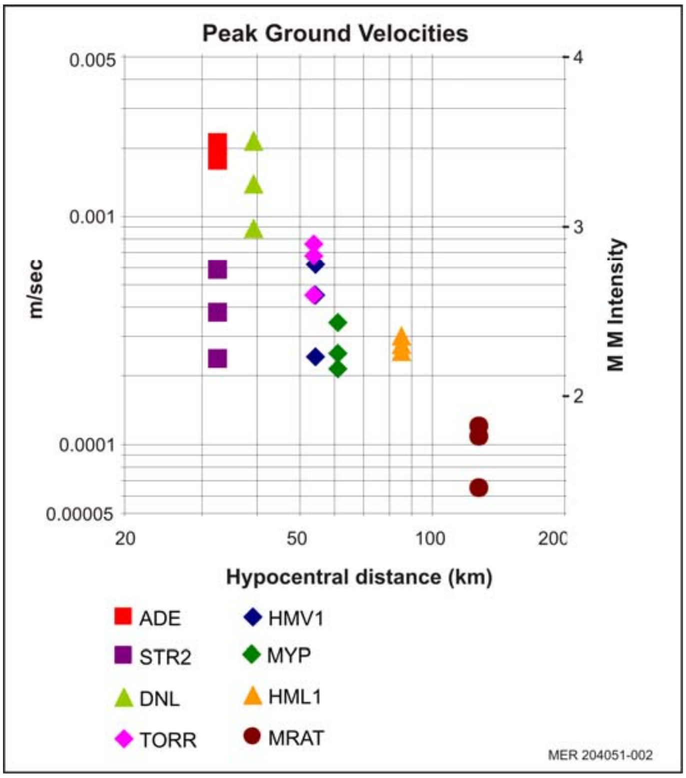

Figure 5 *showing peak ground velocities recorded by seismographs. Each site has 3 axes. Right hand axis values are from Atkinson (2007)*

One insurance assessor estimated that around 1000 claims were likely to have been made. An engineer involved in inspections believed that there were a very small number of cases where minor damage, cracking to walls and ceilings might be attributed to the event.

Past History

The Mount Lofty, Flinders Ranges earthquake zone is moderately active, having experienced six earthquakes in the magnitude range 5 to 6 during the 20th century. The middle of this zone (South Flinders Ranges) experiences a large number of small events regularly, but in the South Mount Lofty Ranges fewer events are recorded. Near Adelaide very few events are recorded or felt. There was a magnitude 6 event (1902, the so-called Warooka earthquake) whose epicentre was probably in Gulf St Vincent, and was probably associated with this zone. The best known event was in 1954 (magnitude 5.4, 20km south of the city). During the 1960s there were two magnitude 4+ events, in the 1970s there were a few magnitude 3+ events, but since then there have been very few events. In November 2009 there was an offshore magnitude 3.4 event. The 16th April event was therefore the strongest shaking experienced in Adelaide since 1954.

There was almost no monitoring prior to 1958, and a three station network was only established in 1964. This means we do not have even a reasonable record of activity prior to, or following the 1954 events. It was thought from a short detailed survey in 1978 that the area close to Adelaide would have numerous small events, but a review (Love 2008) indicated that nearly all the activity was from blasting at local quarries. There was a significant improvement in network sensitivity from 2006 with the installation of the new network. While many more epicentres are now being recorded it is impossible to know at this stage what is normal for the region near Adelaide (figure 6).

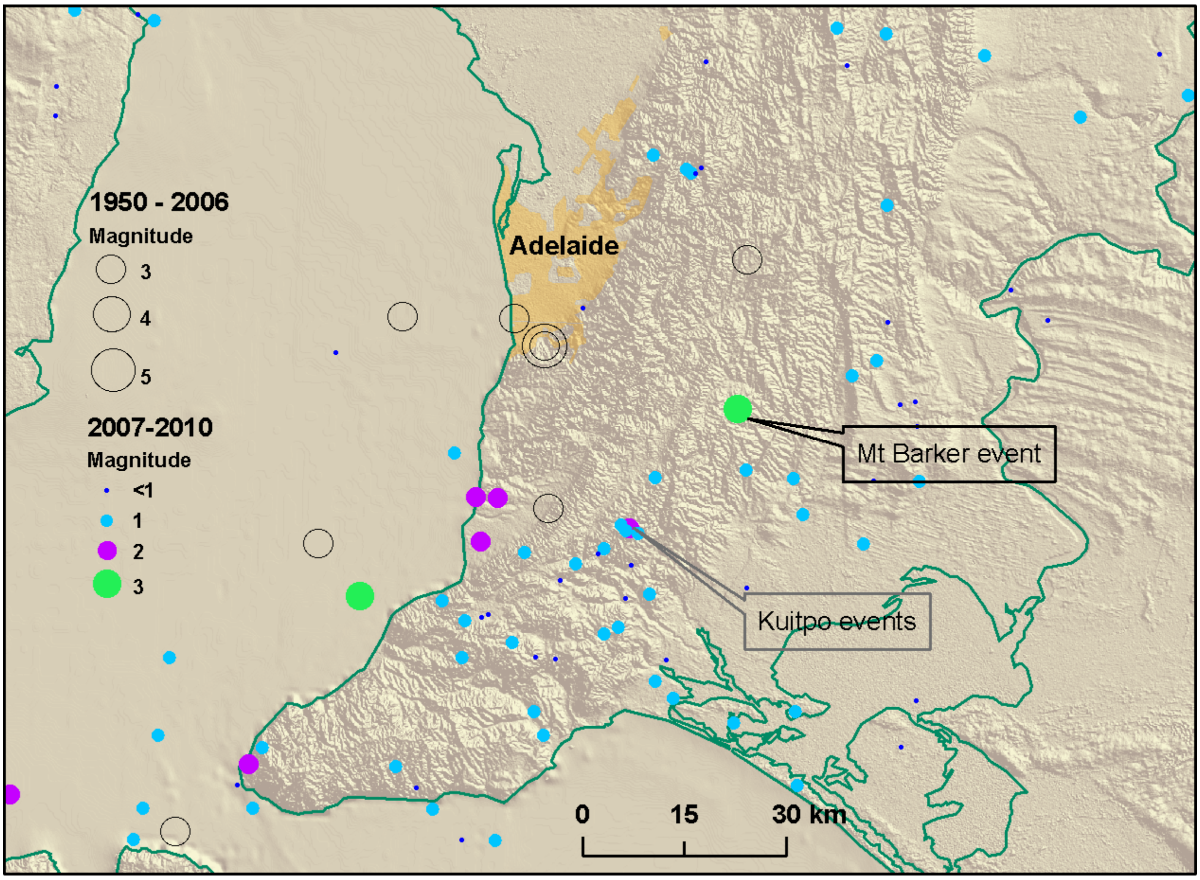

Figure 6 *shows larger earthquakes since 1950, and all activity since 2007. Events at Kuitpo occurred before and after the mainshock (see text).*

For the period 2007 to 2010 there are still very few events near Adelaide, but a moderate number of small events occurred in the ranges further from Adelaide. It is unclear to what extent this is a result of the greater sensitivity of stations further away from Adelaide. More events have been located to the south of Adelaide than elsewhere, but this is partly due to an extra station (HMV1) installed by an interested amateur who regularly searches for local events.

In November 2009 a magnitude 3.4 event occurred just offshore south of Adelaide. This was felt although not widely. In the few weeks before 16th April 2010 three events occurred near Kuitpo. These events were deep (20 to 24km). It was something of a surprise to have a few deep events occur within a short time frame. Following the mainshock no aftershocks were detected. It is expected that events possibly even down to magnitude 0 would have been recognised after the main event. Three temporary recorders were deployed, not to improve detectability, but to improve location accuracy and to determine any focal mechanism. A week later another small deep event occurred at Kuitpo, and in July a small event 17km deep occurred between the Kuitpo events and the Mt Barker event. Are the closest events all related? Are they defining a fault structure? There is insufficient information to conclude anything at this stage.

It has always been a concern to the author that this region within 100km of Adelaide has so few events, yet has had the damaging earthquakes of 1902 and 1954. This is similar to the situation around Newcastle. It suggests either a low b value or temporally varying activity levels or both. There is an indication from recordings between 1964 and 2007 that there may be variation at a decade level, however this is difficult to demonstrate conclusively.

Conclusion

This relatively small event near Adelaide raised a huge amount of community interest, being the largest shaking in the city since the 1954 earthquake. It was sufficiently well recorded by equipment installed over recent years to obtain a reasonable focal mechanism. It appears to be an isolated shock without preceding or following activity. The depth of 26km is thought to be a little unusual, but there is insufficient accurate historical data to support this.

Acknowledgements

We wish to thank ES&S and GA for earthquake information, including assistance immediately following the event, and Alison Wallace. Kim Beven compiled the location and intensity information from GA for the intensity map. John Woodside reported on various inspected buildings.

References

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