

## An ongoing role for intensity data in Australia

**Kevin McCue**

Australian Seismological Centre

### **Abstract**

Some may think that with an extensive network of seismographs and a slowly expanding number of accelerographs, there is no longer any reason to investigate the felt effects of earthquakes past or present in Australia. Limited evidence presented here of past and recent earthquakes demonstrates that felt reports and intensity data are still useful for hazard studies in Australia.

### **An early earthquake?**

On 22 January 1988 between local noon and midnight a series of three large earthquakes shook residents of the small town of Tennant Creek in the Northern Territory. Most buildings in the town, including the local hospital, suffered considerable non-structural damage but remarkably little real damage considering the size and proximity of the three events, rated Mw6.3, 6.4 and 6.7. A 35km long, 2m high fault scarp was formed during the earthquakes.

Have such earthquakes happened near Tennant Creek before? What does the historical record tell us? Extensive study of the 19th century pre-seismograph record continues slowly but surely in Australia, mainly through the examination of old newspapers. One contemporary report has provided the following table:

27 August 1883, earthquake at ~10 am local time		
<i>Place</i>	<i>Distance</i>	<i>Effects</i>
Daly Waters	390km N Tennant Ck	Explosion like blasting and vibration
Alice Springs	450km S Tennant Ck	two distinct explosions
Sheep camp (9miles W Alice Springs)	15km W Alice Springs	ditto
Undoolya	15km E Alice Springs	ditto

The authors of this report of Committee No 1 of the Australasian Association for the Advancement of Science included eminent scientists Biggs, Ellery, Russell, Todd and Hogben. They assigned the terse felt reports Rossi-Forel Intensity 3 which is equivalent to Modified Mercalli (MM) intensity 3. Given the time of day this assigned intensity may be on the low side.

Daly Waters and Alice Springs are almost equidistant north and south of Tennant Creek so an earthquake midway between them could have caused the effects. The authors mention that Daly Waters was struck by another earthquake at about midnight the previous day, sufficient to wake the sleepers (McCue, 2001).

The date however seemed familiar. Rynn et al. (1987) report on a large Queensland earthquake on 29 August 1883 (local date) and mentioned the eruption of the volcano Krakatoa in Indonesia, disavowing any connection as postulated in the media at the time. Wikipedia says: The volcano began erupting around 19 June. At about 1pm (local time) on 26 August, the volcano went into its paroxysmal phase. On 27 August, the volcano entered the final cataclysmic stage of its eruption. Four enormous explosions took place at 5:30 a.m., 6:42 a.m., 8:20 a.m., and 10:02 a.m. The worst and loudest of these was the last explosion. Wikipedia also reports that: the explosion was heard in Perth, WA.

It seems safe to conclude that the widespread felt effects in the Northern Territory in this case were associated with the Krakatoa eruption and not a local earthquake as previously postulated (McCue, 2001).

Sites of known large earthquakes, such as Tennant Creek, have been assigned higher hazard in the Australian Loading Code (AS1170.4) than those where there is no evidence of current or previous seismicity. We should still be cautious of accepting the alternative suggestion that sites of large recent earthquakes are relatively less hazardous.

### **A detective study unveils an aftershock**

The following reports were published in an undated contemporary Newspaper (possibly the Adelaide Advertiser). This extract of the relevant page was provided by the SES coordinator for Mt Gambier, Greg Malseed, during AEE2004 in Mt Gambier.

EARTH TREMORS AT MOUNT GAMBIER – An earth tremor, which, in certain parts of the town, appears to have been of greater severity than in others, occurred at Mt Gambier at about half past ten on Thursday evening. Bottles, window frames, etc, rattled considerably, while in one or two cases small articles were thrown down, and the tremor was accompanied by a rumbling noise. Another tremor is reported at half-past twelve on Friday night, and three hours later, at half past three, a further shock, slight but unmistakable, was experienced, there being perceptible oscillating motion of the ground as well as the peculiar rumbling noise previously noted. Tremors were also felt at Burrungull, Millicent, Beachport, Lucindale, Kingston and Robe, and at Harrow, across the Victorian border.

MILLICENT

(from our own correspondent) June 7.

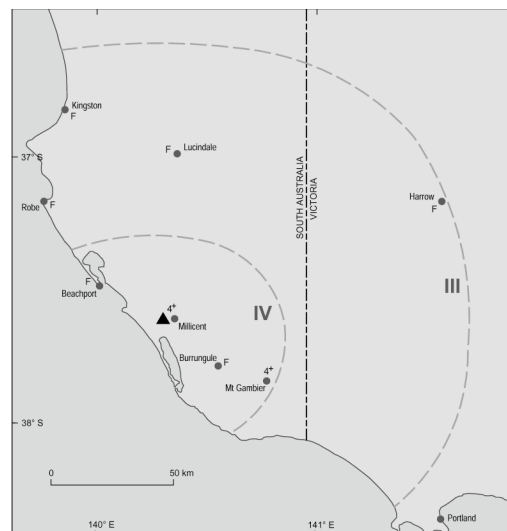
On Thursday evening about 10:30 we had a pretty sharp shock of earthquake, which lasted several seconds. The shock awoke several, so from this its force may be estimated. It is reported that another shock was felt on Friday.

As to the date: the year was obtained from other articles in the same newspaper extract describing the coming diamond jubilee of Queen Victoria. She was crowned in 1837 and the diamond anniversary is 60 years. Under one column was the sub-heading Monday June 7, and in 1897 June 7 was indeed a Monday. The local time 10:30 pm, based on longitude, corresponds to about 13:00 UTC (Standard time had not yet been introduced into Australia).

Yet a third article in the newspaper extract may be interpreted as implying that this earthquake was more widely felt in Victoria than just at Harrow (and is interesting because it refers to an earlier undocumented damaging earthquake that ought to be investigated further).

THE FIRST EARTHQUAKE – An impression has prevailed (says the Hamilton Spectator) that the earthquake recently experienced was the first of any importance remembered in Victoria, but this is altogether erroneous. .... The oldest colonist Mrs Stephen Henty remembered when residing at Portland, a very similar earthquake occurring there late in February or early in March 1837..... First came a noise like subterranean thunder then followed the rocking motion of the house in which the flooring boards of hardwood were seen to part and the soil from below to protrude through the seams. This was succeeded by a fall-down of plaster .....

Intensities were assigned from the newspaper reports and plotted in the figure opposite. There are few points on the resultant map, and at most places we only know that the tremor was felt, but the intensities at Mt Gambier and Millicent can be estimated at MM IV to V (people awoken, things fell off shelves). The fact that at least one of the small aftershocks was felt in both Mt Gambier and Millicent supports a location near these towns. That it was felt in western Victoria and along the Limestone Coast of South Australia justifies the empirical magnitude (McCue, 1980) determined from the felt area as ML 4.9, surely an under-estimate!



This earthquake with its own small aftershock sequence turns out to have itself been an aftershock of the large Kingston-Beachport earthquake, magnitude ML ~6.5 on 10th May 1897, for which an isoseismal map was compiled in the early 1970s (McCue, 1975).

### **A recent micro-earthquake in the ACT - 3 October 2003**

Small earthquake stirs suburbs in inner South was the headline of the Sunday Canberra Times on 5 October 2003. The article went on to report: residents of Forrest and Deakin reported hearing loud explosions as an earth tremor shook parts of Canberra yesterday morning.



DATE: 3 OCT 2003  
TIME: 22:25:10 UTC  
MAGNITUDE: 1.4 ML(I)  
LOCATION: 35.326° S, 149.107° E  
DEPTH: 3±1 km

Nearly two months passed before the author made a concerted effort by phone and a newspaper appeal to try to outline the felt area since only five reports were emailed to Geoscience Australia. ACT Police did not keep any written records because there was no damage despite the hundreds of calls they received. Confirmation that the source was an earthquake was of more than passing interest to ACT emergency services personnel who were investigating the possibility of an explosion at an embassy or consulate. Most of the diplomatic offices and residencies are concentrated in the inner south suburbs of the National Capital.

Several Deakin residents, retired geologists with BMR, reported that there was a big bang, houses shook and windows rattled violently, dogs stopped barking for a minute and a TV nearly fell on the floor from a cabinet. One reported that small ornaments and tables moved about 10 cm, implying a good intensity MM4. Another Deakin resident and his wife felt a bump and heard a thump and they wondered if a hot-air balloon had landed on the roof. The dishes rattled and they checked the house to make sure the verandah hadn't fallen off! A family member in bed did not feel a thing.

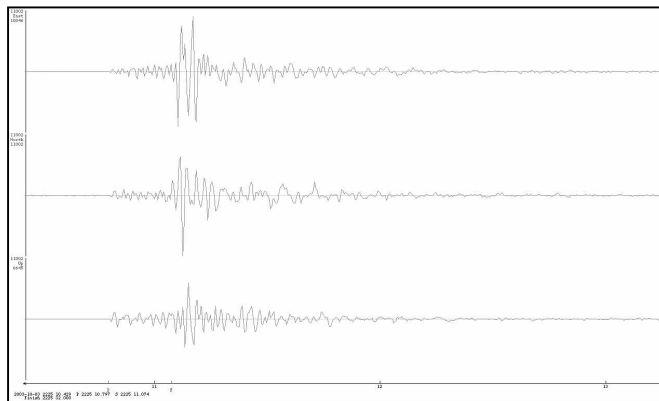
A Garran resident was woken by the loud thump and thought something under the house had fallen down. An ANU Professor of Geophysics and resident of Hughes heard a bang but thought it was thunder, not an earthquake (rated MM2) whilst a former BMR seismologist, recognised that the sharp shock he heard in Griffith was a small earthquake (MM3-).

Another Griffith resident, in bed, heard a loud thump and thought her husband had had a fall in the kitchen (MM2). He, getting breakfast, didn't feel it.

The centre of the isoseismal map is about 3km south of the epicentre computed by Geoscience Australia and under Red Hill in the Canberra Nature Park. This is about 1km from the surface trace of the Deakin Fault mapped by Abell (1991). He identified 5km of sinistral slip with considerable vertical movement but the dip direction is not marked so the earthquake cannot definitely be attributed to movement on the Deakin Fault.

An accelerogram was recorded in the basement of nearby Parliament House (PHB on the map) and a strong Rg phase indicated that the focus was between 1 and 4 km deep. Security staff at Parliament House did not feel the earthquake.

This shallow depth supports the intensity map location rather than the seismograph location which is poor due to the lack of ACT seismographs and the geometry of GA's regional stations (the closest three are co-linear and only one of them within 100 km of Canberra).



Accelerogram recorded at Parliament House (PHB) Canberra, 3 October 2003

Some Australian cities are not well monitored for earthquakes or terrorist explosions. The National Capital unfortunately is one of them as the evidence presented above demonstrates.

## **Conclusion**

Historical felt reports of earthquakes are particularly important in Australia because of the very short instrumental and written record here. The contemporary reports of ground shaking and audible noise in Tennant Creek and South Australia in the 19th century are our only record of possible seismic activity there prior to installation of seismographs. Later research can add value to the earlier interpretations, either by establishing locations and magnitudes of these events, or discounting entirely their seismic origin, as in the case of the 1883 Tennant Creek 'earthquakes'. The more modern example from Canberra convincingly demonstrates that there are circumstances when the best epicentral location can be obtained from felt intensity reports even in this age of digital seismology. Moreover, with few accelerograms available of moderate to large earthquakes, these data are vital for verifying ground motion models. Indeed this is recognised in the US by the US Geological Survey who have invested considerable effort and resources to produce near-real time felt intensity maps on their web site (<http://earthquake.usgs.gov/dyfi>).

## **References**

- Abell, R.S., 1991 Geology of the Canberra 1:100,000 Sheet area. BMR Bulletin 233, page 88.
- McCue, K.F., 1975. Seismicity and seismic risk in South Australia. University of Adelaide, Report ADP 137.
- McCue, K.F., 1980. Magnitudes of some early earthquakes in south-eastern Australia. *Search*, 11(3), 78-80.
- McCue, K.F., (compiler) 1996. Atlas of isoseismal maps of Australian earthquakes Part 3. AGSO Record 1995/44.
- McCue, K.F., 2001. Do large earthquakes recur in Australia? in *AES Newsletter* 3/2001 p 7.
- Rynn, J.M.W., Denham, D., Greenhalgh, S., Jones, T., Gregson, P.J., McCue, K.F., and Smith, R.S., 1987 Atlas of isoseismal maps of Australian earthquakes Part 2. BMR Bulletin 1987/222.