

# **The Bredbo NSW earthquake near Canberra, 31 January 2016**

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## **Abstract**

In early 2016, a small earthquake struck the Monaro District of NSW south of Canberra and was widely felt. The earthquake details:

Near Bredbo NSW earthquake

31 January 2016 at 04:40 ESST (30 January 2016 at 17:39:13 UTC).

Epicentre (ASC) 36.0°S, 149.25°E (10km SE Bredbo), depth 20km,  
magnitude ML3.6.

There were no aftershocks. This earthquake was well recorded thanks to its proximity to Canberra where there are government, state agency and independently operated seismographs. Its study has elicited useful information on the regional principal stress orientation, important information for hazard analysis and it sheds light on the relationship between current earthquakes and ancient faults.

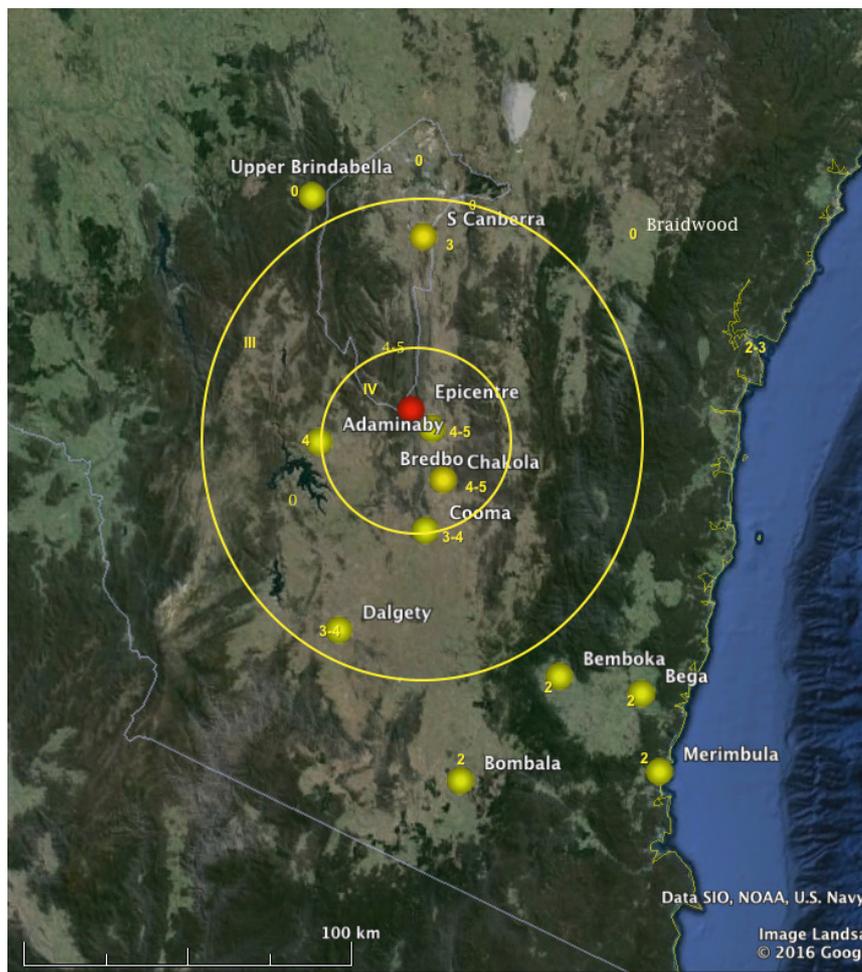
**Keywords:** Seismicity, focal mechanism, active faults, earthquake hazard modelling

## FELT REPORTS AND ISOSEISMAL MAP

Wireless media, police and government agencies fielded many reports of the effects of the earthquake but this information is usually lost, apart from what is printed the local newspapers and on-line. Typical stories are reported below.

### *Cooma Monaro Express online*

*Residents across the region were woken in the early hours of Sunday morning by a 3.6 magnitude earthquake that shook houses and rattled windows. The earthquake's epicentre was recorded just outside Bredbo with residents as far field as Merimbula reporting they had felt the seismic activity. Geoscience Australia first recorded the earthquake shortly after 4.30am on Sunday.*



Residents took to social media over the weekend, eager to ascertain just how far afield the earthquake was felt.

At the time of going to print the *Cooma-Monaro Express* Facebook page had almost 9,000 hits on a post regarding the earthquake with residents of Bredbo, Adaminaby, Cooma, and even Bemboka feeling the shaking.

**Figure 1** Isoseismal map of the Bredbo earthquake using the modified Mercalli intensity scale and felt reports compiled by the author by phone and from the media. The information collected by Geoscience Australia was regrettably not made available.

One lady from Adaminaby, as reported in the *Express*, said there was a 'massive rattle in her lounge room windows' while a Murray Street resident commented that she was left quite shaken from the incident. Many people initially thought it was a continuation from the weekend's storms while others simply slept through the event.

*Bega District News online*

*To top off the wild night, a [3.5 magnitude earthquake hit Adaminaby](#) in the Snowy Mountains around 4.40am, but with Bega Valley residents reporting they felt the low rumbling even here.*

The resident of a homestead in the Gudgenby Valley said “*it woke me up, which is a feat in itself given I am a heavy sleeper! Very loud rumble and lots of items rattling in the house, no damage however.*” The noise woke all 4 occupants of Lachney’s Cottage 1.5km from Dalgety. They thought it was a distant explosion and then the house shook and windows rattled briefly. They didn’t realize it was an earthquake till they stopped at Bredbo on their way home and heard about the earthquake there.

It did not awaken the hard working farmer and his family at Rocky Plains contacted by phone, nor residents in North Canberra, Queanbeyan, Braidwood or in the Brindabella Valley, 5km south of the bridge across the Goodradigbee River.

*Sydney Morning Herald online*

*A minor earthquake that rattled a small Snowy Mountains town on Sunday morning was felt as far north as Weston Creek in Canberra, a senior seismologist says. ...."It was felt certainly as far as the coast off to the east, as far as Merimbula and as far southern Canberra, Weston Creek even," he said..... Bredbo Inn manager Elaine Robertson said she was woken by what sounded like a truck passing by.*

*"The whole building shook. It lasted all of a few seconds before it passed through. It sounded like a truck," she said. She said the whole town felt it and other towns were shaken. "Someone coming through from Bombala said they felt it there," she said.*

<http://www.smh.com.au/nsw/36-magnitude-earthquake-hits-near-bredbo-south-of-canberra-20160131-gmibil#ixzz3zkNgNBkM>

A report solicited from Berridale (southwest of Cooma) indicated that it was strong enough to wake him but that it lasted just a few seconds.

## **LOCATION OF THE FOCUS AND THE MURRUMBIDGEE FAULT**

A well-defined epicentre has been determined using arrival times from selected stations equally distributed around the epicentre, more than 40 seismographs within 250km including GA, SRC, ANU and ASC stations. The closest stations were about 70km away. In the GA location, analysts used stations out to 1200km from Bredbo while SRC limited theirs to 300km. Important considerations for a satisfactory location are to: use phase arrivals from stations symmetrically distributed around and at an equal distance from the epicentre, weight the nearest stations higher than far stations, use as many phases as possible, adopt the best local crustal model. The total number of stations is not important, nor are distant stations.

The computed focal depth of 23km is not especially well constrained because the nearest stations were relatively distant at 40km. The local crustal model is well determined (Collins, 1988) and the use of PG and Pn phases does help control the depth. The lack of surface waves gives some confidence that the focus was not very shallow. The isoseismal map is not consistent with a very shallow focal depth either supporting the SRC and ASC solutions which put it in the mid-crust. The lack of aftershocks is another indicator that the focus was not very shallow.

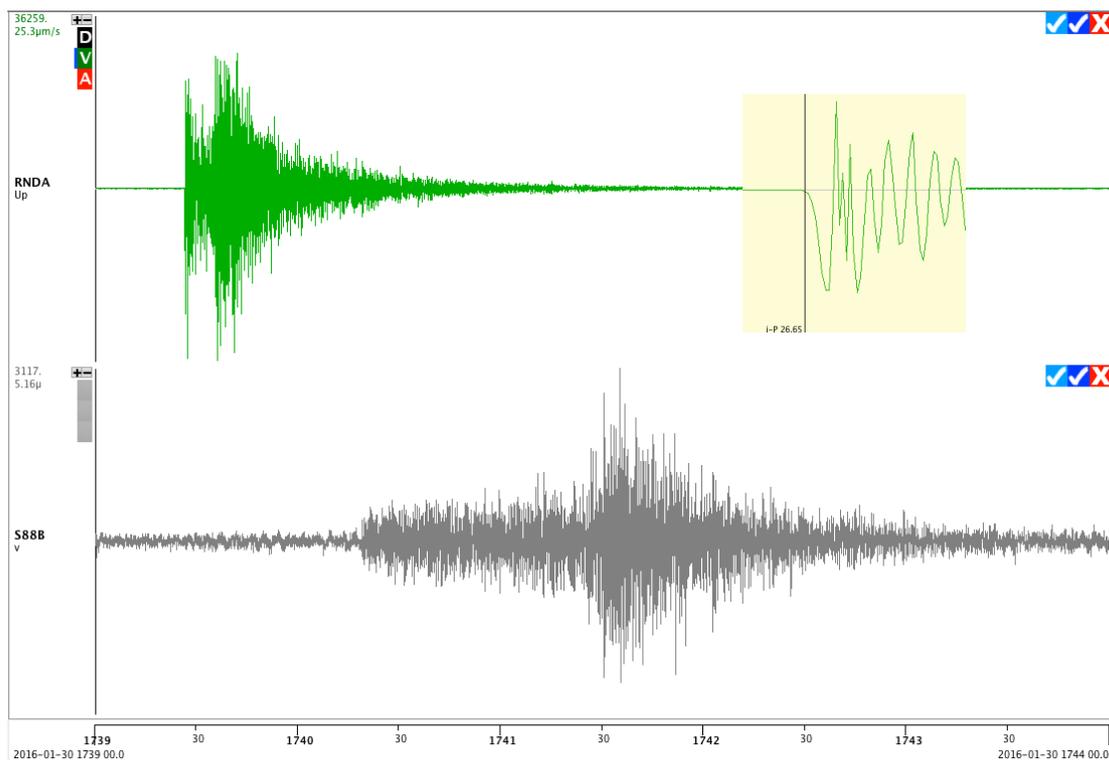
Neither the location nor the mechanism, discussed below, would suggest an association of the hypocenter with the largest fault in the region, the Murrumbidgee

Fault that controls the course of the river of the same name. The Murrumbidgee Fault is in one assessment a large meridional high-angle normal fault with Upper Silurian dacite porphyry on the eastern or downthrown side and Ordovician sediments and Middle Silurian Volcanics on the west (Malcolm, 1954). Alternatively, Foster and others, 1999 have a very different model: ... the west dipping Murrumbidgee fault on the east side of the Cooma complex ... of thrusts ... that sole(s) into relatively deep levels of the crust.

That the earthquake occurred at a mid-crustal depth is important information for hazard analyses in the region. Earthquake foci aren't all shallow, like the UK (Ansell and others, 1986) but unlike Western Australia.

## THE FOCAL MECHANISM

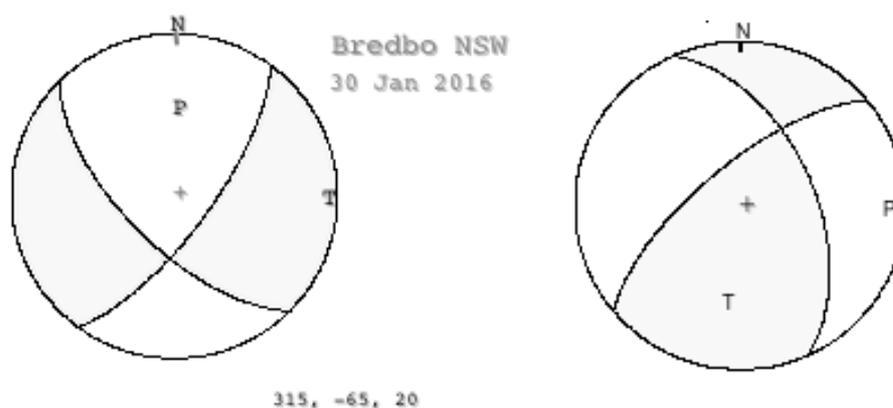
The 13 first motions (Table 1) include one compression at S88B (neglecting the unchecked station AUDAR), and an SRC reported compression on Wambrook station. The rest are dilatations with an unambiguous dilatation on RNDA (yellow box) that indicates it is well away from a nodal plane (useful information). Despite the lack of compressions the solution is reasonably well-controlled. The mechanism departs significantly from that usually accepted for SE Australia, a thrust mechanism with a horizontal principal stress acting in a NW-SE direction. In this case  $\sigma_1$  is almost north-south and there are strong strike-slip and tensional components.



**Figure 2** Seismograms recorded at RNDA, Aranda ACT (top) at ~80km and the reversed polarised S88B, Sandon Vic., ~ 450km away. A detail of the RNDA first P arrival is shown in the yellow box, the first ground motion almost due north of the epicentre is strongly down indicating it is not near one of the nodal planes.

**Table 1** P-wave first motions

Station	First motion	Azimuth	Distance km
AUMHS	- Melrose HS	0	75
CAN	- Canberra ACT	355	74
AUMTS	- Mt Stromlo	355	74
AUSIS	- RSES	0	74
AUSMG	- Jindabyne	228	78
MILA	- Mila NSW	180	122
RIV	- Riverview NSW	40	300
CNB	- Canberra ACT	20	72
AUDAR	+ Daramalan ACT	0	75
DLN	- Dalton NSW	356	130
RNDA	- Aranda ACT	355	79
SYDH	- Sydney NSW	40	290
S88B	+ Sandon Vic	230	483



**Figure 3** Focal mechanism of the Bredbo NSW earthquake (left) using local stations and the first motions tabulated above; and the more normal focal mechanism of the Wee Jasper earthquake (right) of April 2012.

An ML3.7 earthquake near Wee Jasper NSW on 19 April 2012 at 1909 UTC was felt throughout Canberra and suburbs to the east but its focal mechanism was quite different, the P and T axes reversed and more ‘normal’ for the region.

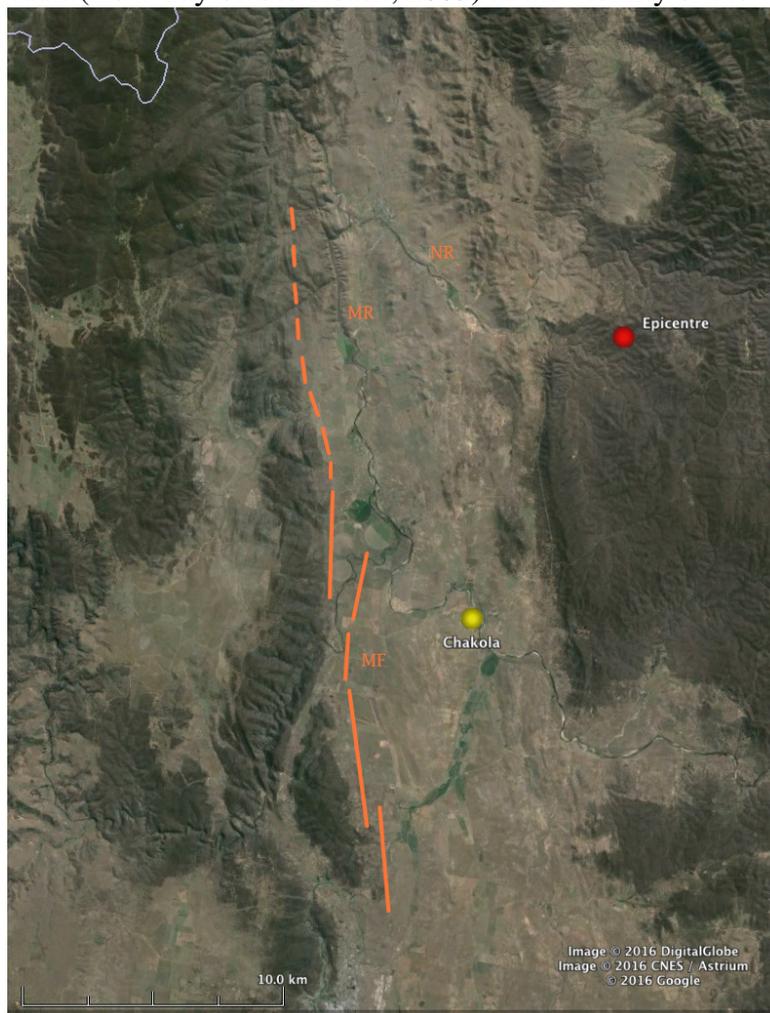
Whether the stress changes with time or over relatively small distances in Australia is not known because to date there were too few seismographs to undertake focal mechanisms for small earthquakes.

### RELATIONSHIP TO KNOWN FAULTS

Earthquakes occur on pre-existing faults, don’t they? That’s the common perception among seismologists. In intraplate regions with possibly geologically recent rejuvenation of tectonic stress this may not be true, for a number of reasons; the stress direction may have changed relative to the azimuth of the fault, the faults may have healed (no longer active), the crust may not have uniform strength, etc. Alternatively, an earthquake may rupture previously intact rock.

I have plotted the mapped fault (from Taylor and Roach, 2003) in the vicinity of the epicentre onto the topographical map from Google Earth, with the epicentre marked. The upper shorter-dashed fault line is extrapolated.

In this case the nearest large mapped fault is the Murrumbidgee Fault (MF) which has strongly influenced the course of the Murrumbidgee River (MR), the largest river in this part of NSW. The Numerella River, marked (NR), has been captured by the Murrumbidgee and its course is also fault controlled. Other conjugate faults can be inferred from the Google map.



**Figure 4** Epicentre (red dot) in relation to the Murrumbidgee Fault (orange dashed line MF). The tip of the ACT/NSW border is outlined at the top left of the picture.

## HISTORICAL EARTHQUAKES NEAR BREDBO

The area is not noted for its earthquakes but a small earthquake occurred near Bredbo in 1928, on 13 February at 08:45 UTC, as noted in the extract of the Cooma region newspaper. The magnitude has been assigned 3 until more information is unearthed.

*The Manaro Mercury, and Cooma and Bombala Advertiser* Friday 20 April 1928, page 2.

*Local and General News*

*A distinct shock of earthquake was noticed at the residence of Mr. J. J.*

*Harnett, of Bredbo, on Friday last at about 6.45 p.m. The quake was travelling from South-East to North-West, and lasted a few seconds.*

The on-line GA database lists 5 earthquakes above magnitude 3.9 within 50km of Bredbo since 1958. The largest was the May 1959 Berridale earthquake, magnitude ML5.3 (RIV). The shaking was strong in Bredbo and reported on throughout the ACT. Some seismologists attribute this earthquake to the partial filling of the Eucumbene reservoir.

## **DISCUSSION**

A few decades ago, this much information could not be gleaned about such a small earthquake near Canberra, or in most other parts of Australia. Expansion of the GA network, privately owned seismographs, the Seismometers in Schools Program and introduction of the Public Seismograph Network have dramatically increased the available data allowing for reasonably well defined focal coordinates and focal mechanisms to be determined.

Earthquake focal mechanisms are the best indicators of the principal stress directions within the crust with no modification by near surface processes such as topography, weathering and climate, or climate induced pore fluid pressure changes.

Even such small earthquakes can contribute to the debate about whether earthquakes occur preferentially on mapped faults, now that we can accurately locate them in three dimensions and compute their mechanism. They also allow more public debate and information sharing about felt earthquakes than was previously possible. People are interested in earthquakes and other natural phenomena. The information makes it easier and faster to compile isoseismal maps and informs decision making for earthquake hazard analyses.

The price of seismographs and running them has decreased so that more and more people are indulging in this hobby. The data management exercise is not yet so successful and various data formats have to be laboriously merged to make use of it all. Geoscience Australia no longer do this, they use only their own station data, so locations are compromised.

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## **ACKNOWLEDGMENT**

Phase arrival times or waveforms are often shared between network operators and researchers but not always. I thank Geoscience Australia, SRC and the ANU's Seismometer in Schools Program for making some of their data available. The PSN network is a very useful addition to the data pool but on this occasion the contributing local stations were not operational.