Observations of the Bowen, Queensland ML5.8 2016 Earthquake and its ongoing aftershock sequence.

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Abstract

On 18 August 2016 a magnitude ML5.8 earthquake occurred 63 km East of Bowen, Queensland, in the Whitsunday Passage, between the Great Barrier Reef and the coast, about 950 km NNW of Brisbane. Of the 14 events recorded in the east coast region of Queensland since1880, this event was the second largest. The event appears to have a strike slip focal mechanism, similar to another (magnitude 5.3) event which occurred about 150 km west of this location in 2011. A magnitude 3.6 event about nine months prior to the event is the only possible foreshock identified. Detailed examination of data from two seismographs approximately 70 km from the epicentral zone has enabled the identification of about 1300 mostly small aftershocks, and the location of about 200 of them. The aftershocks cluster around 19.87^{o}S. 148.8^{o}E, which is also the probable location of the main event. The distribution of aftershocks is probably over a much smaller area than a simple plot suggests, because of relatively large location uncertainties, The aftershock sequence is ongoing 720 days after the main event, producing up to three events per day of magnitude ML1.4 and greater. This paper reports on this ongoing aftershock sequence and describes the methodologies used to detect, locate and quantify the aftershock events.

Introduction

Seismic environment/recent seismicity

There have been 14 earthquakes of ML 5.0 or more in the Queensland eastern coastal region since 1880 (Figure 1), beginning with two Gayndah events in August1883, (larger was ML 5.6). The largest event was ML 6.0 off Gladstone, on 6 June 1918. Since 2011 there have been 6 events, of which the Bowen event (ML 5.8, 18 August 2016) was the largest. Three of these (largest ML5.4) were off Fraser Is, in southeast Queensland, in July & Aug 2015, and these events had a long aftershock sequence (Borleis and Dimas, 2016). The ML 5.3 event of 16 Apr 2011 was only about 150 km west of the 2016 Bowen event, and also had many aftershocks. A temporary network installed by Geoscience Australia (GA) within 4 days of the 2011 event recorded over 300 low magnitude events (Mathews et al, 2016). There may be a NNE trend in the aftershock distribution for the 2011 event. The ML 5.8 2018 event is the second-largest since 1880, and is discussed below. The coastal region of Queensland might now be recognised as an active region, although it was not classified as such in a review of Australian seismicity by Leonard (2008).

Most of the more recent events in the Bowen region have also been recorded on two stations located in Bowen (BW1H, BW2S), which were installed in the early 1990s as part of an Australia-wide “Joint Urban Monitoring Project” (JUMP). These stations were about 65 km southwest of the epicentral region of the 2016

Figure 1. Magnitude ≥ 5.0 events in eastern Queensland since 1880. Red circles = earthquakes, Blue triangles = seismic stations.

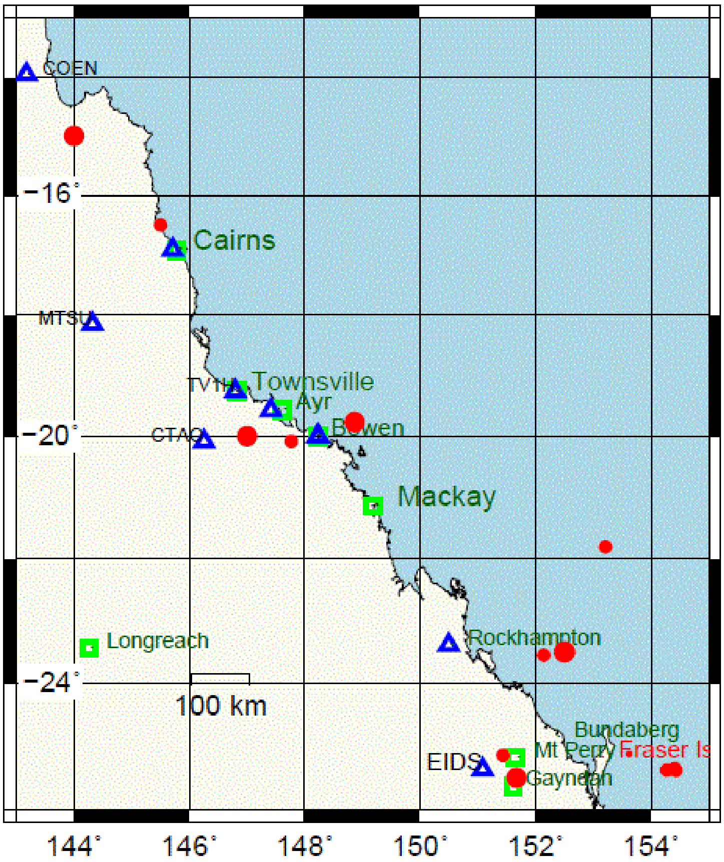
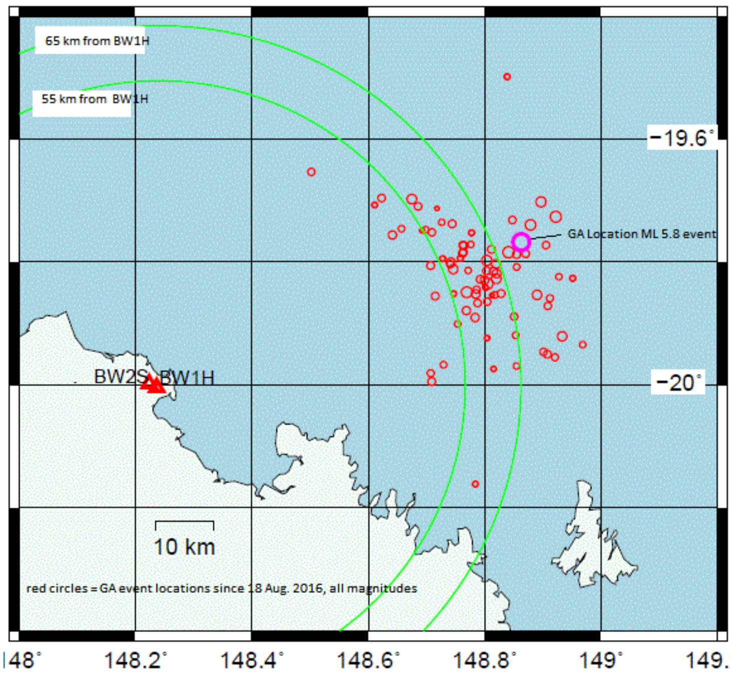
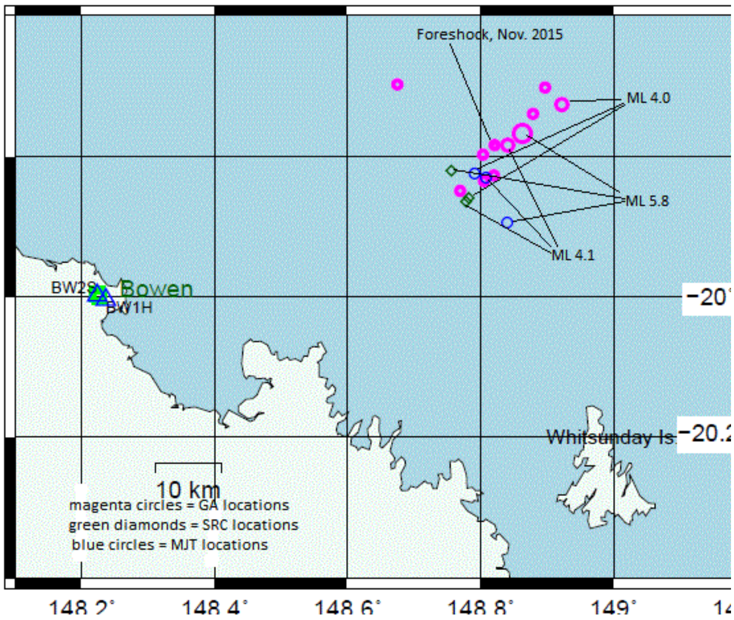


Figure 2. All GA locations near Bowen, from August 2016 to October 2018



event (Figure 2). The data are stored at the IRIS Data Management Centre, and the first author (MLT) has accessed this data to assist in the analysis to be presented below.

Figure 3. GA locations near Bowen, ML ≥ 3.5, since 1990



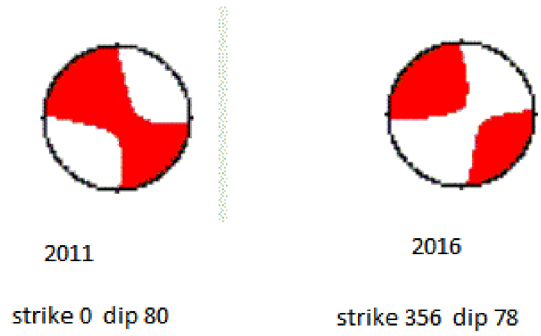
The August 2016 Bowen event

The event occurred at 1430 hrs local time, and was reported felt from the Sunshine Coast (north of Brisbane) to north of Townsville, with some residents reporting objects being thrown off shelves. GA located ~ 30 aftershocks in the 24 hours following the event and about 80 events in total (Figure 2). The largest aftershock was ML 4.1, about 14 hours after the main event, and the larger aftershocks (ML ≥ 3.5) appear to define a north-south lineation. An aftershock survey was mounted by GA, the results of which will be presented in the 2016 Australian Seismological Report (A. Thom, in prep.)

GA located the ML 5.8 event using 27 stations, but the closest stations (Townsville and CTAO) were over 200 km distant. A location by the Seismological Research Centre (SRC), Melbourne, placed the event about 12 km southwest of the GA location (Figure3). The event has also been located by MLT to a location near the SRC location, and the full MLT solution is shown in Appendix A. Event locations are summarised in Table 1. Some of the variations in computed locations may be due to variations in the earth models used in the computations. GA has used the IASPEI91 model (Kennett & Engdahl, 1991), whereas the SRC used NEQ2A model and MLT has used SEQ2A (The models are shown in Appendix B). The RMS of residuals for all solutions is quite high, suggesting epicentral uncertainties of the order of +/- 10 km.

Figure 2 shows GA locations for all events of ML 3.5 and above in the Bowen region since 1990. Only one of these (18 November 2015) occurred prior to the August 2016 ML 5.8 event, and there appear to have been no smaller foreshocks in the weeks leading up to the event. The November 2015 event was very close to the location of the August 2016 event and should probably be considered a foreshock. The plot of GA epicentres would appear to indicate a northeast trend to the epicentres, though other locations, discussed below, do not necessarily support this interpretation.

Figure 4. Focal plane solutions by GCMT



Earthquake Focal Mechanism

The Global Central Moment Tensor (GCMT) focal mechanisms for the 2011 and 2016

Table 1. Some location data for significant events near Bowen

Date, Time & Magn	auth	Lat. Deg. S	Long. Deg. E	closest station	dep km	Stn/phase /rms	model used	Approx. Uncert.	comment
18 Nov 2015	GA	19.785	148.821	BW1H	0	11/17/ .67	iaspei		Only foreshock
18 Aug 0430	GA	19.786	148.863	TV1H	0	27/29/0.79	iaspei	+/- 10 k	Appendix A
(ML 5.8)	SRC	19.821	148.756	BW1H	10	18/30/0.52	NEQ2A	+/- 5 km	The main event
	MLT	19.895	148.840	BW1H	22	24/20/0.49	SEQ2A		
18 Aug 0530	GA	19.727	148.922	TV1H	0	9/11/0.69	iaspei	+/- 20 k	
(ML 4.0)	SRC	19.860	148.782	BW1H	5	9/14/0.45	NEQ2A	+/- 5 km	
18 Aug 1827	GA	19.785	148.841	BW1H	0	17/20/ .53	iaspei		Largest a/s
(ML 4.1)	SRC	19.865	148.778				NEQ2A		
10 Dec 1625	GA	19.698	148.675	BW2S	10	4/7/0.91	iaspei		W of trend line
	SRC	19.753	148.798	BW2S	6.4	8/15/0.25	VIC5A	+/-3 km	

events were extracted from the GCMT catalogue, and compared (Figure 4). These appear to suggest very similar faulting mechanisms, interpreted as indicating strike slip faulting, as suggested by Mathews et al.,(2011). The compression direction appears to be northeast-southwest, which is consistent with the findings of Hillis et al., (1999) who interpreted a north-northeast direction of maximum horizontal stress in the Bowen Basin.

Increasing the seismic catalogue in the region with the assistance of Bowen data

Daily 24-hour records for the BW1H and BW2S were downloaded and visually scanned in 10-minute windows, after the data had been filtered from 2Hz to 10Hz to eliminate local noise and spikes. This often resulted in a collection of relatively good quality earthquake waveforms, with sharp P and S phase arrivals. The event plotted in Figure 5 is an example.

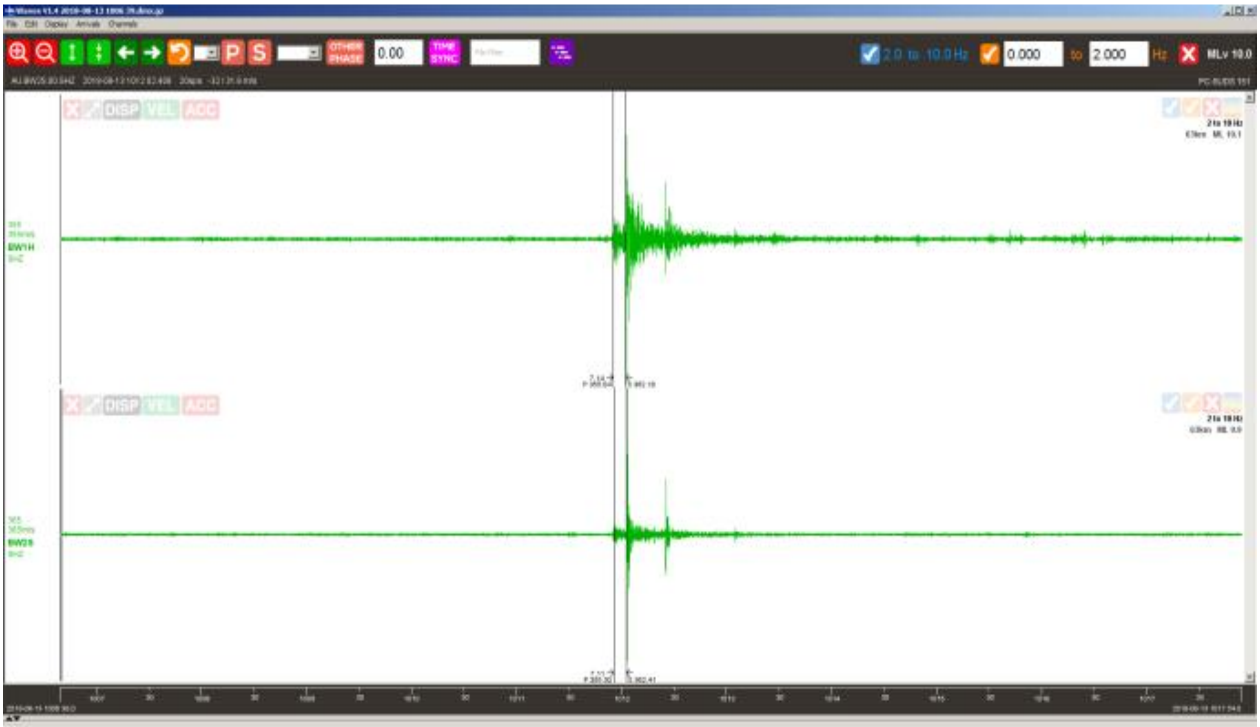


Figure 5: BW1H and BW2S records of a magnitude ML2.1 Aftershock.

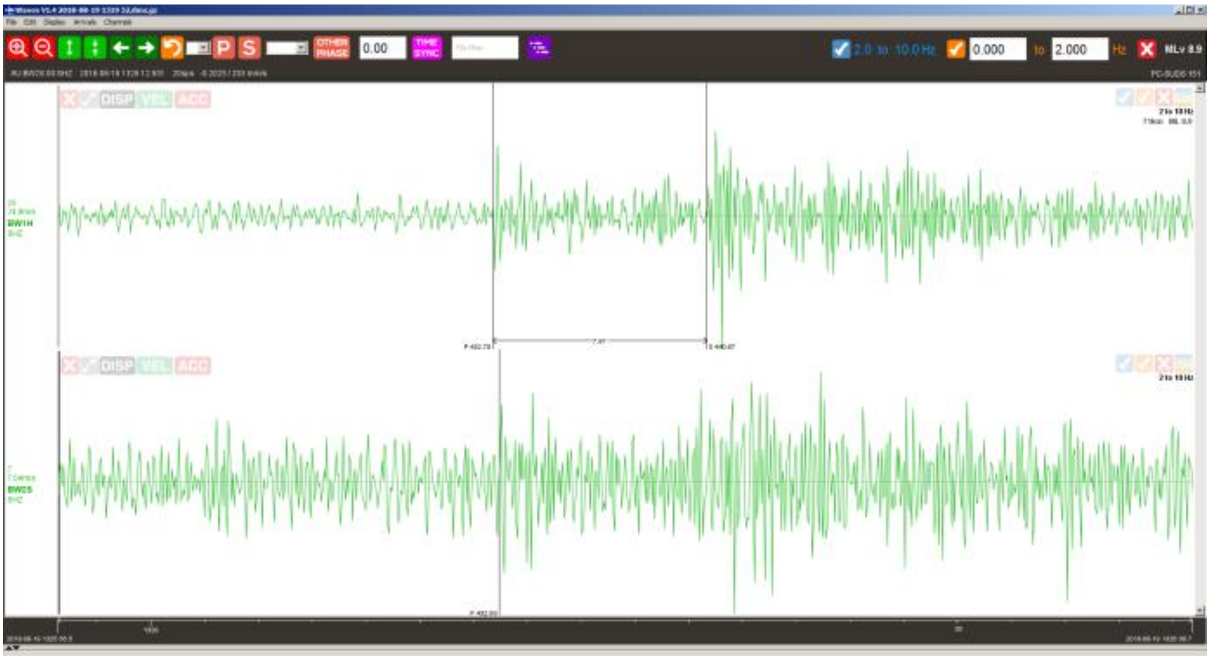
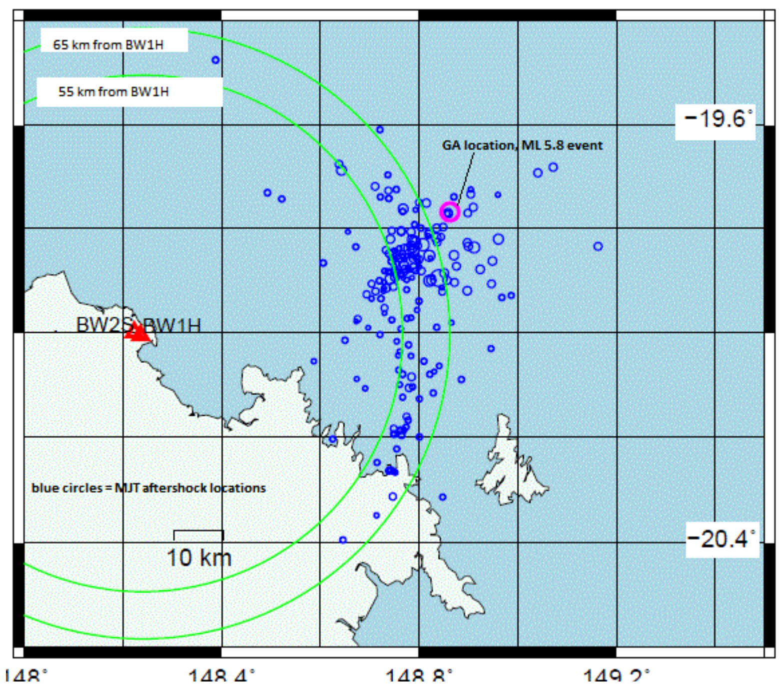


Figure 6: BW1H and BW2S records of a magnitude ML1.4 Aftershock.

Aftershock events of magnitudes ML2.0 and above showed up clearly on both stations (see Figure 5) whereas events from Magnitudes ML1.4 to ML2.0 were often only just discernible on the BW2S station after the time scale had been enhanced, as in Figure 6.

Careful perusal of the records has resulted in the identification of more than 1340 mostly small aftershocks, of which only ~ 80 were previously identified/located by GA. Using techniques described later, it is estimated that about 380 of these events have an ML of 2.0 or more. Whenever sufficient records of an event could be obtained from more distant stations such as CTAO, TV1H, MTSU, and CN1H (Figure 1), locations were computed using the EQLOCL program (© SRC, Melbourne). Just under 200 of these have been located/relocated, as shown in Figure 7. They are fairly dispersed, but with a concentration near 148.80°E 19.87°S. Because of their small magnitudes, the locations can be expected to have relatively large uncertainties.

Figure 7. Aftershock locations ear Bowen by the CQSRG



For comparison, aftershocks from the GA catalogue plotted in Figure 2 could be interpreted as showing two trends, to the NE and NW, but with a concentration at approximately the same location as the MLT locations.

Estimating aftershock spread from S-P times

Statistical analysis of the more than 1300 detected events showed that the S-P times (at BW1H) had an average of 7.62 seconds, with a standard deviation of 0.42 seconds. As it seems probable that most of the S-P times scaled have potential scaling errors of ~ +/- 0.1 secs, this range in the S-P times is probably due to the natural variation in the station-to-event radial distance.

Equating S-P times to epicentral distance will depend on the earth model used and the assumed focal depth. Initial calculations suggest that a range of 7.2 to 8.0 secs for the SEQ2A model equates to a distance range of 54.5 to 60.5 km, and for the IASPEI model, the range is 57.5 to 64 km, assuming a shallow focal depth. These epicentral distances are in reasonable agreement with the event concentrations noted on Figures 2 and 7, and suggests that the events remote from these concentrations may have larger errors. Note that there is a N-S trend for many of the events in Figure 7, but there is poor control in that azimuth from the available (distant) seismographs.

Typical location solutions obtained in the relocation process are shown in Appendices A and C. Appendix A shows the location solution for the main ML5.7 earthquake, and Appendix C shows a typical solution for an ML2.0 event.

A reasonable unconstrained depth determination, at 22±7 km, could only be obtained for the main (ML5.8) event. The location depths for all other events were manually constrained to 10 km.

Distribution of aftershocks over time

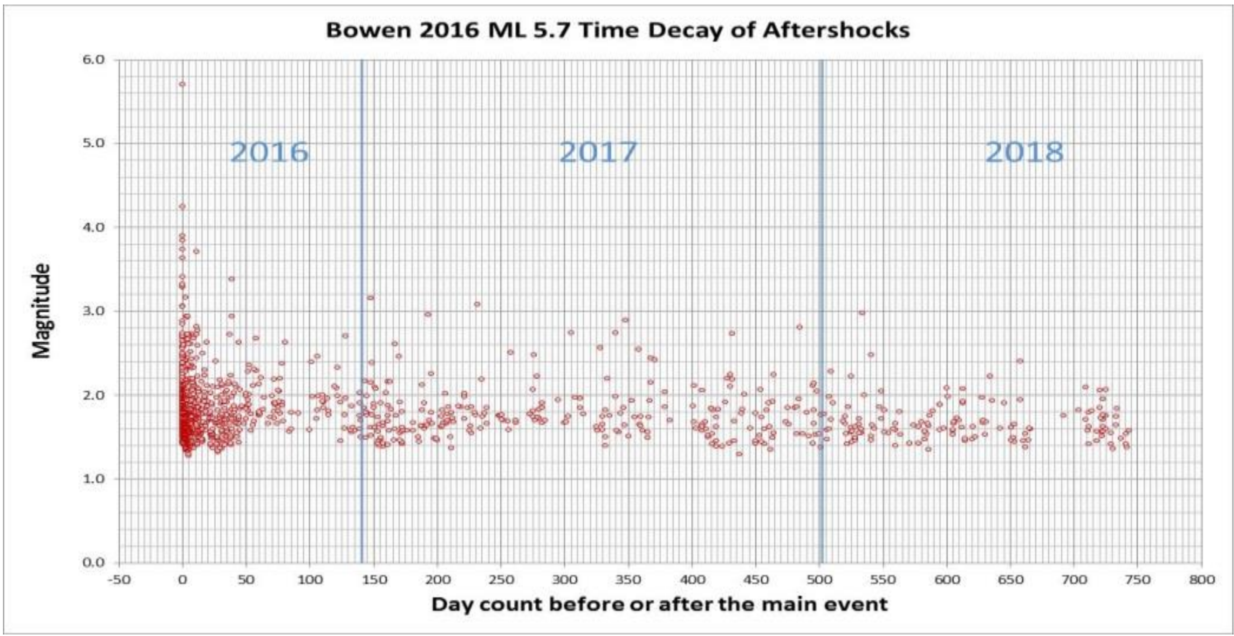


Figure 8: Time decay graph of the Bowen 2016 aftershock sequence.

A better indication of the number and magnitude of the Bowen 2016 aftershock sequence is given in Figure 8. It is clear that the sequence is ongoing, and will likely persist into the future. It may be that, as seems to be the case with the sequence following the February 2015 ML 5.2 near Mt Perry, the ongoing Bowen "aftershock" events will establish as the ongoing ambient seismicity of the area.

The possibility of small foreshocks before the main event was checked by visual inspection of daily 24-hour records for the two months prior to 18 August 2016. However, no earthquakes in the Whitsunday Passage area were identified.

Figure 9 shows that 98% of the Bowen 2016 aftershock events are of magnitude ML2.9 or less; and are therefore below the threshold limit for GA's normal location procedures. Many other events below ~ML 1.2 probably occurred, but were not detected by the above procedures.

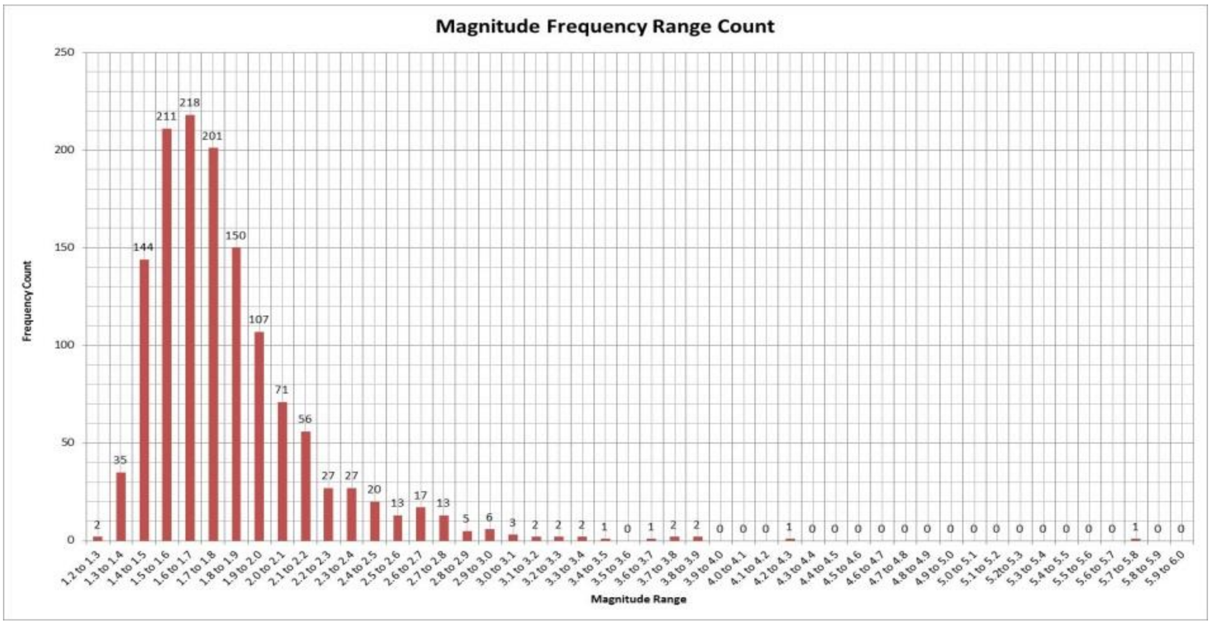


Figure 9: Magnitude frequency histogram of the Bowen 2016 aftershock sequence.

Magnitude determinations

Due to the lack of calibration data for the Bowen UMP stations, a nonstandard method was devised to quantify the event magnitudes. This method relied on the accuracy of the preferred magnitudes published by GA in the range ML1. 9 to Mwp5.8.

This was done by graphing the maximum amplitude of the Bowen station seismogram in the time range encompassing the P arrival and the S wave train, filtered in the 2Hz to 10Hz frequency range, against the published GA preferred magnitude, and fitting a power curve to the plot in Microsoft® Excel®. The result was the calibration equations shown below.

$$ML_{BW1H} = 0.8469 A_{BW1H}{}^{0.1401}$$

and

$$ML_{BW2S} = 1.1126 A_{BW2S}{}^{0.1164}$$

These two equations provided coefficients of determination (R^2) of 0.83 and 0.77 respectively, indicating a strong correlation between the station maximum amplitudes and the published GA preferred magnitudes (Figures 10, 11). This strong correlation is further supported by a comparison of the calculated Bowen station magnitudes with the GA published magnitudes, as shown in Figure 12.

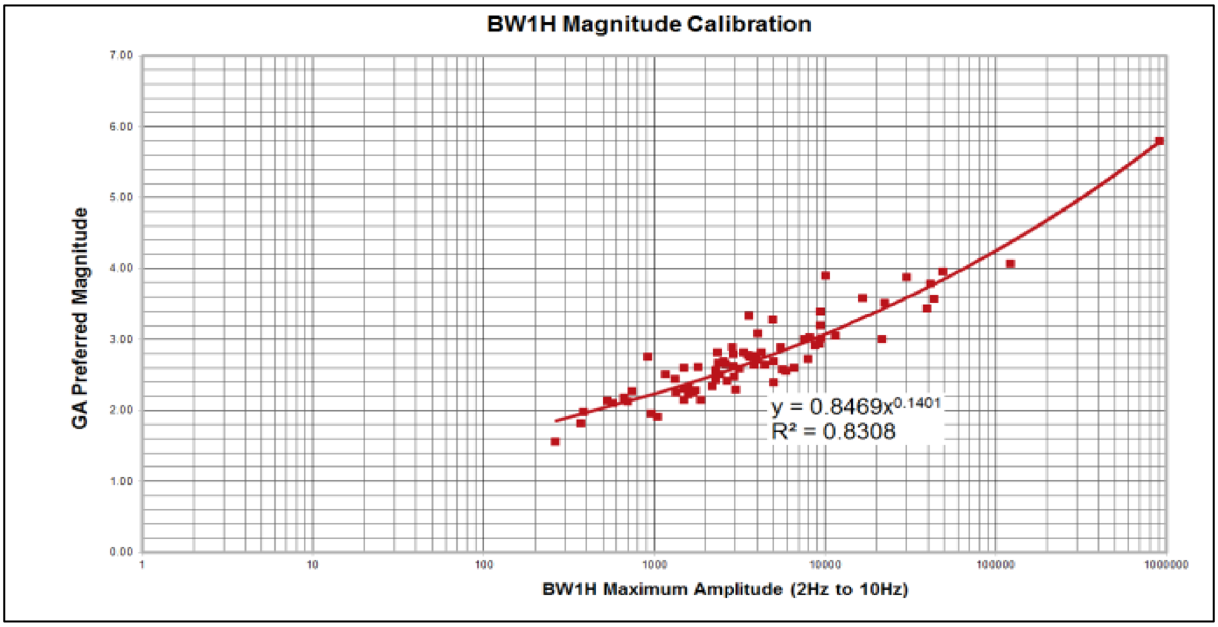


Figure 10: Magnitude calibration of the BW1H station.

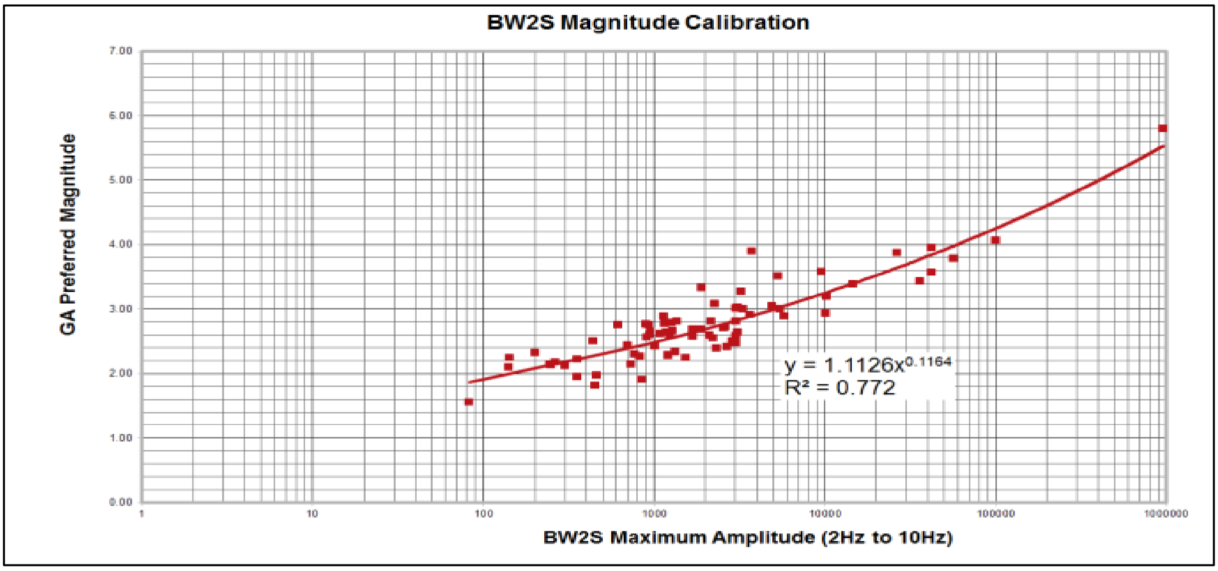


Figure 11: Magnitude calibration of the BW2S station.

This method of magnitude determination assumes that all of the measured events have occurred within a station to event radial distance spread that does not affect the calculation; and this assumption seems to be justified given the strong coefficients of determination that have been indicated by the comparison statistics.

Discussion

Figure 8 indicates that the seismicity declined after the main event as expected, but after about 2 months, seemed to reach a “steady state” and seismicity has continued at relatively constant rate

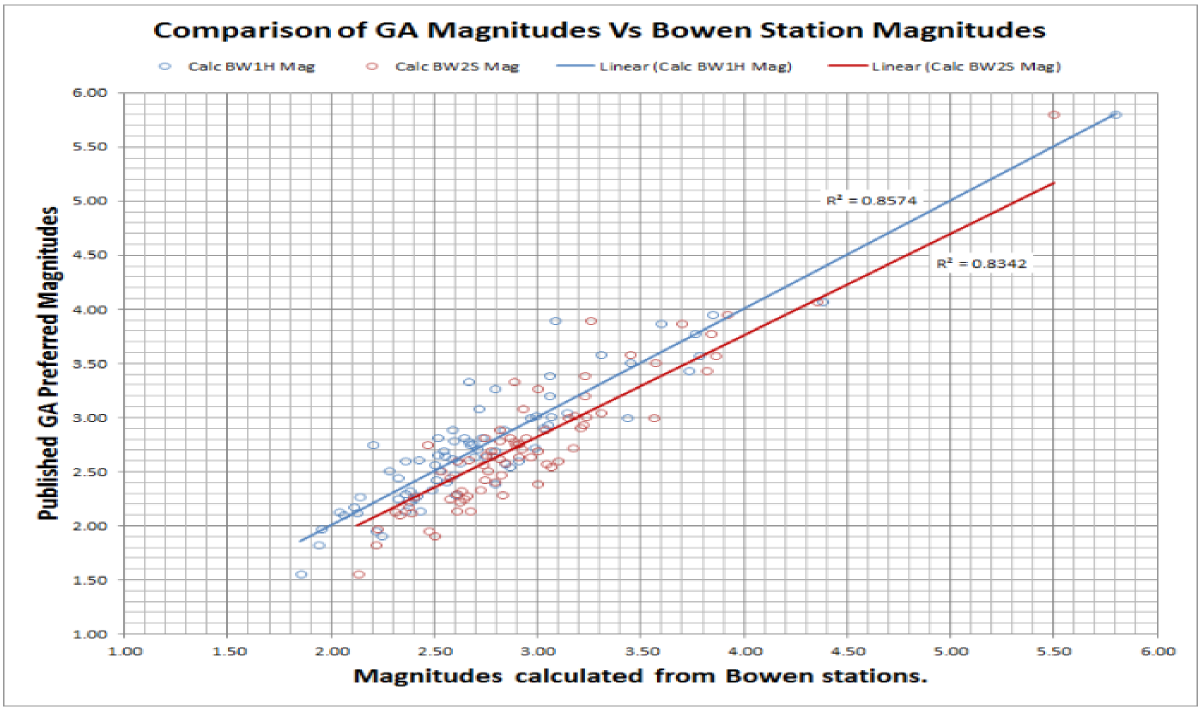


Figure 12: Linear regression of the Bowen station magnitudes against the published GA magnitudes.

In general there are insufficient numbers of instrumental seismographs in Queensland to adequately study and document the aftershock sequences of large earthquake events. It is just fortuitous that the Bowen 2016 ML5.7 earthquake was in the proximity of the two Bowen UMP stations, thereby providing a unique opportunity to continuously monitor the aftershock sequence.

Are these Events Aftershocks or Something else?

The occurrence of the Bowen 2016 ML5.7 earthquake and its aftershock sequence has provided a unique opportunity for monitoring such seismic processes in Queensland, in particular, and Australia in general. Similar opportunities presented with the 2015 ML5.2 Mt Perry earthquake and the three ML 5 Rainbow Beach earthquakes later in 2015. One of us (MLT) was able to closely monitor the Mt Perry sequence, and has catalogued 124 aftershock events from ML0.4 and greater. However, because there are no seismographs close to the Rainbow Beach region, only the largest 57 aftershocks (ML > 1.9) have been detected and located following those earthquakes.

There has been some recent debate considering whether Australian main earthquake aftershock sequences are, in fact, typical aftershock sequences, or alternatively, reactivations of seismic zones following a long period of quiescence. For instance, Clark et al (2007) make the following observation.

> *While the suite of active fault behaviours may vary across Australia, one individual fault characteristic appears to be common to most Australian intraplate faults studied … . Active periods comprising a finite number of events are separated by typically much longer periods of quiescence … . (Clark et al, 2007, Section 6)*

This observation has been noted as long ago as 1997, as commented on by Clark and Leonard (2014).

> *Rare paleoseismic data indicate pronounced temporal clustering of large earthquake events across all geological environments within Australia …with a finite number of relatively closely-spaced events being separated by much longer periods of quiescence … .(Clark & Leonard, 2014, Introduction)*

The characteristics of the sequence of earthquakes observed following the 2016 ML5.7 Bowen earthquake, and the available seismic history of the area, indicate that this earthquake sequence was precipitated by the 2016 earthquake, and would not have occurred otherwise. However, it is not clear whether the sequence can be considered an aftershock sequence, or a reactivation of the normal seismic behaviour of the area following a period of quiescence. The presence of an event close to the main shock location, but nine months before it, would appear to indicate the presence of an intermittently active fault.

Conclusions

In general, there is insufficient density of instrumental seismographic monitoring in Queensland to study and document the aftershock sequences of large earthquake events. In the fortuitous situation of the Bowen 2016 ML5.7 earthquake the adjacent proximity of the two Bowen UMP stations provided a unique opportunity to continuously monitor for aftershock events. This paper presents the results of that monitoring for 750 days following the main event. Present indications are that the Bowen 2016 aftershock sequence will continue into the future. It is speculated that the Bowen 2016 aftershock sequence represents the front end of a continuing seismic reactivation of a zone that has been relatively quiescent at least since the late 1800s.

Acknowledgements

Data from the SunWater seismograph network stations at Dalbeg (DLBQ), Burdekin Falls Dam (BURD), and Ukalunda (UKAQ) assisted in providing data for 35 of the relocations, until mid-2017. Thank you to Clive Collins for constructive editing of the report, and David Love for helpful comments on Fault Plane solutions. Thanks also to the staff of the SRC for their assistance with location and model data.

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Appendix A: EQLOCL Location solution for the main ML5.7 event.

```
Date            2016-08-18                    Event type  = E
Origin Time     0430  8.42   +-   1.13
Zone                    55
Easting             692.67   +-   5.03        Longitude     148.840
Northing           7799.10   +-   4.49        Latitude      -19.895
Depth                22.20   +-   6.74

Arrival times    = 24          S.D. = 0.489       Seismographs = 20
Nearest recorder =    64.4 km  Gap  = 196.5 deg   Accuracy = E
Effects Code     =             Imax =  0          Fault =

  64 km  E ( 79 deg) of  BW1H
QUEENSLAND
 941 km NW (332 deg) of BRISBANE
 270 km  E ( 86 deg) of CHARTERS TOWERS
  Record      Dur     Sync     Unc     Resp    Seismometer      Recorder         Pol
MAGNITUDES
Code       R        ML       MD       MB       MS       MW       MN

No magnitudes known                              Assign ML  5.7
```

DATA USED

Code	Wave	AT	+-	WT	CT	DT	Dist	Azim	Ad	Ae
BW1H	P	19.40	0.10	1.31	19.13	0.27	64.4	258	14.2	31.8
BW1H	S	26.92	0.10	1.18	27.28	-0.36	64.4	258	14.1	32.6
PETE	S	29.95	0.10	1.16	29.85	0.10	74.3	215	11.9	31.8
TV1H	S	63.55	0.10	1.06	63.85	-0.30	225.7	287	-34.3	44.2
CTA	S	74.38	0.10	1.04	73.72	0.66	271.3	265	-34.3	44.2
TINA	P	71.26	0.10	1.10	70.70	0.56	460.9	310	-35.1	42.3
TINA	S	116.41	0.10	0.99	117.05	-0.64	460.9	310	-34.7	43.3
CN1H	P	71.49	0.10	1.09	71.46	0.03	467.0	314	-35.3	42.2
CN1H	S	118.75	0.10	0.98	118.42	0.33	467.0	314	-34.7	43.2
MTSU	P	77.70	0.10	1.08	77.80	-0.10	513.4	291	-36.3	42.1
FRED	P	94.90	0.10	1.06	94.25	0.65	636.6	151	-38.9	42.5
EIDS	P	96.53	0.10	1.06	95.72	0.81	647.8	159	-39.0	42.5
FS03	S	164.51	0.10	0.95	164.54	-0.03	655.1	152	-35.9	41.9
RMQ	P	106.52	0.10	1.05	106.24	0.28	729.5	180	-39.9	42.1
BOON	P	106.85	0.10	1.04	107.08	-0.23	736.2	159	-39.9	42.1
WSD	P	123.11	0.10	1.03	123.90	-0.79	870.6	155	-40.3	43.0
QLP	P	124.04	0.10	1.03	124.72	-0.68	877.0	211	-40.3	43.0
BSHS	P	125.36	0.10	1.03	124.82	0.54	878.0	152	-40.3	43.0
WRP	P	125.50	0.10	1.02	126.21	-0.71	889.0	157	-40.3	43.0
WNP	P	127.89	0.10	1.02	128.56	-0.67	907.6	153	-41.1	43.0
WPC	P	131.70	0.10	1.02	131.40	0.30	930.2	159	-41.1	43.0
WPC	S	226.85	0.10	0.92	226.40	0.45	930.2	159	-37.1	42.3
HNZD	P	140.80	0.10	1.01	141.26	-0.46	1009.1	154	-41.3	43.4
ARMA	P	164.55	0.10	1.00	164.75	-0.20	1198.0	167	-41.5	43.8

24 times used, S = 0.489

Deferred Data

PETE	P	21.91	0.10	1.29	20.59	1.32	74.3	215	12.0	30.9
BURD	P	39.08	0.10	1.19	36.63	2.45	196.8	245	-33.0	42.6
BURD	S	63.35	0.10	1.07	57.49	5.86	196.8	245	-34.3	44.2
TV1H	P	41.56	0.10	1.17	40.31	1.25	225.7	287	-33.0	42.6
CTA	P	47.94	0.10	1.15	46.02	1.92	271.3	265	-33.0	42.6
GD1S	P	78.08	0.10	1.09	75.78	2.30	498.9	151	-36.0	42.1
GD1S	S	131.17	0.10	0.98	126.21	4.96	498.9	151	-34.8	42.9
MTSU	S	127.91	0.10	0.98	129.87	-1.96	513.4	291	-34.9	42.7

MSHS	P	81.64	0.10	1.08	80.19	1.45	531.1	167	-36.7	42.0
MSHS	S	139.26	0.10	0.97	134.21	5.05	531.1	167	-34.9	42.6
FRED	S	163.27	0.10	0.95	160.10	3.17	636.6	151	-35.8	41.9
EIDS	S	171.59	0.10	0.95	162.78	8.81	647.8	159	-35.9	41.9
FS03	P	97.94	0.10	1.06	96.70	1.24	655.1	152	-39.1	42.5
RMQ	S	185.21	0.10	0.94	181.42	3.79	729.5	180	-36.1	42.3
BOON	S	180.00	0.10	0.94	182.91	-2.91	736.2	159	-36.1	42.3
WSD	S	210.60	0.10	0.92	212.98	-2.38	870.6	155	-36.6	42.3
QLP	S	224.96	0.10	0.92	214.44	10.52	877.0	211	-36.6	42.3
BSHS	S	218.68	0.10	0.92	214.64	4.04	878.0	152	-36.6	42.3
WRP	S	213.94	0.10	0.92	217.11	-3.17	889.0	157	-36.6	42.3
COEN	P	124.53	0.10	1.02	126.50	-1.97	890.9	316	-41.1	43.0
COEN	S	214.44	0.10	0.92	217.61	-3.17	890.9	316	-37.1	42.3
WNP	S	230.20	0.10	0.92	221.31	8.89	907.6	153	-37.1	42.3
QIS	P	134.29	0.10	1.02	136.04	-1.75	967.0	264	-41.1	43.0
QIS	S	226.39	0.10	0.91	234.69	-8.30	967.0	264	-37.1	42.3
HNZD	S	249.32	0.10	0.91	244.04	5.28	1009.1	154	-37.4	42.8
ARMA	S	275.16	0.10	0.90	285.95	-10.79	1198.0	167	-37.7	43.6
CMSA	P	178.16	0.10	1.00	180.31	-2.15	1326.7	193	-41.9	44.7
CMSA	S	318.66	0.10	0.90	313.98	4.68	1326.7	193	-38.3	43.8
KOUN	P	212.51	0.10	1.00	214.55	-2.04	1614.0	95	-44.3	46.4
LHI	P	219.22	0.10	1.00	218.09	1.13	1643.4	143	-44.3	46.4
NFK	P	277.55	0.10	1.00	277.97	-0.42	2179.7	121	-50.8	54.6

Appendix B. Earth models used in EQLOCL solutions

(a) IASPEI earth model (used by Geoscience Aust.)

Depth	Pv (km/s.)	Sv (km/s.)
	5.8	3.36
20		
	6.5	3.75
35		
	8.04	4.47

(b) SEQ2A earth model (used by CQSRG)

Depth	Pv (km/s.)	Sv (km/s.)
	5.85	3.38
10		
	6.67	3.85
30		
	7.95	4.59

(c) NEQ2A earth model (used by the SRC)

Depth	Pv (km/s.)	Sv (km/s.)
	4.5	2.9
1.0		
	5.94	3.4
17.0		
	6.62	3.6
40.0		
	7.82	3.95

Appendix C: A typical solution for an ML 2 event

Date 2016-08-18 Event type = A

Origin Time 0737 26.91 +- 3.57
Zone 55
Easting 687.63 +- 31.25 Longitude 148.791
Northing 7810.48 +- 11.49 Latitude -19.792
Depth 10.00 +- 19.78 N

Arrival times = 7 S.D. = 0.404 Seismographs = 4
Nearest recorder = 62.7 km Gap = 282.6 deg Accuracy = G
Effects Code = Imax = 0 Fault =

62 km E (68 deg) of BW1H
QUEENSLAND
953 km NW (332 deg) of BRISBANE
266 km E (84 deg) of CHARTERS TOWERS
Record Dur Sync Unc Resp Seismometer Recorder Pol
MAGNITUDES
Code R ML MD MB MS MW MN

No magnitudes known Assign ML 2.0

DATA USED

Code	Wave	AT	+-	WT	CT	DT	Dist	Azim	Ad	Ae
BW1H	P	36.68	0.10	1.31	36.52	0.16	62.7	247	9.1	9.1
BW1H	S	44.19	0.10	1.18	44.68	-0.49	62.7	247	-27.7	27.7
PETE	P	39.06	0.10	1.28	39.31	-0.25	81.2	208	7.1	7.1
PETE	S	49.31	0.10	1.15	49.33	-0.02	81.2	208	-27.7	27.7
BURD	S	79.12	0.10	1.07	78.34	0.78	197.2	241	-27.7	27.7
TV1H	P	59.29	0.10	1.18	59.07	0.22	217.5	285	-33.3	33.3
TV1H	S	82.50	0.10	1.06	82.81	-0.31	217.5	285	-39.8	39.8

7 times used, S = 0.404

Deferred Data

BURD	P	57.61	0.10	1.19	56.20	1.41	197.2	241	-17.0	17.0
CTA	P	68.62	0.10	1.15	65.37	3.25	267.4	262	-33.3	33.3
CTA	S	95.88	0.10	1.04	93.59	2.29	267.4	262	-39.8	39.8