A review of seismicity in the Norseman region of Western Australia, 1970 – 2018.

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Abstract

A region about 70 km southeast of Norseman is of interest because it has been the source of four magnitude 5 events since 1985. Some new phase information for earthquakes in the area has been obtained from a temporary network installed by the Australian National University, and from the Public Seismic Network in WA. Epicentres from the region are reviewed, and some events have been relocated including data from the above networks. This has resulted in some large changes to some epicentres. One aftershock in 2015 was relocated accurately, at 32.60°S, 122.54°E, and it is suggested this may be a common location for all events. A partial focal mechanism was also obtained, suggesting east-west compression.

1 Introduction

Figure 1 shows magnitude 5 and above earthquakes in southern Western Australia since 1970, and it can be seen that the Norseman region has four of the 17 events plotted, three of which occurred between May and July of 2016. A magnitude (ML) 5.6 in the area in 1985 was the largest earthquake in Australia for the year, and an isoseismal map for it was presented in the Annual Seismological Report for 1985 (McCue, 1989).

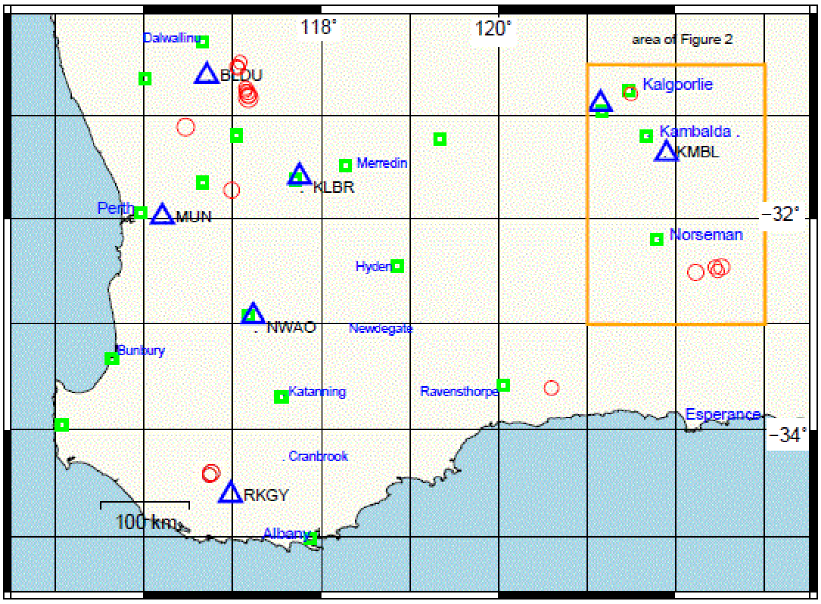

Figure 1 Magnitude 5+ earthquakes since 1970 and seismograph stations.

A review of Western Australian seismicity (1849-1960) by Everingham and Tilbury (1972) does not show any seismicity in the region, but their report relies strongly on collected felt reports from residents and travellers in the region, and is therefore not authorative. The region does not fall within one of the four Australian zones of elevated seismicity defined by Leonard (2008), but does fall within a region (“zone 6”) suggested by Gaull & Micheal-Leiba (1987), which extends northeast from Ravensthorpe to Norseman.

When lesser magnitude events in the Geoscience Australia (GA) catalogue in the Norseman region are plotted there are many more events, most of which are assumed to be aftershocks of the larger events. Because of the remoteness of the earthquakes, and lack of close monitoring stations, the earthquake location quality is generally poor. This report aims to review available epicentral data, and using additional data, determine if events apparently remote from the large events may in fact be related to them.

History of the Geoscience Australia network

Seismic monitoring in WA was the responsibly of the Mundaring Geophysical Observatory (MGO), from 1959 to April 2000. At the beginning of the study period (January 1970), the only permanent seismographs operating in southern WA were at Mundaring (MUN, opened 1957), Kalgoorlie (opened 1964) and Meekatharra (opened 1968). By the time of the first significant earthquake (1985), seismographs had been added at Narrogin (NWAO 1976), Ballidu and Kellerberrin (BLDU KLBR 1982) and Rocky Gully (RKGY 1984). The only station east of the Norseman area was at Forrest (1989), over 500 km east of Norseman. The network was analogue (paper charts) until about 1995, after which digital recording was gradually phased in. Epicentres were determined graphically by MGO staff using triangulation on a map with a compass. In about 1990 the EQLOCL program was introduced. The velocity model used until 1990 was WA1, a simple single layer crustal model, assuming a crustal velocity of 6.3 km/secs, and after 1989, the WA2 model was used (Dent, 1989).

By 2000, the network was fully digital, and on 28th April 2000 the MGO was closed, and all analysis since then has been done by GA in Canberra. However the network has not expanded, and apart from upgrades and slight changes in location, the network in 2018 is not significantly different from its configuration in the 1980s. There have been many changes in the Kalgoorlie area, with the original KLG station being superseded by KLGA, COOL, WOOL, and finally KMBL near Kambalda (2001). The velocity model used for locations by GA after 2015 was the IASPEI91 model (Kennett & Engdahl, 1991), which uses much lower crustal velocities than the WA2 model.

Other seismographs providing data

Apart from the National (GA) seismograph network, there are other possible sources of waveform data. The Australian National University (ANU) deployed a large network of field seismographs (~50) in the region between November 2013 and February 2015 as part of an investigation into crustal structure. These recorded a ML 2.5 event southeast of Norseman, which can therefore be very well located. Other smaller, unlocated events may also be present in the ANU data.

In response to the three magnitude 5 events in mid 2016, GA deployed four stations in the epicentral area. The data from the deployment were not available for this study, but are expected to be included in Thom (2018).

The Australian Centre for Geomechanics/Public Seismic Network (ACG/PSN) consisting of low-cost seismographs has grown over time from its inception in 2006 (Dent et al., 2006). It now numbers 10 stations in southern WA, with most stations being in the wheatbelt area, east of Perth. However two stations in the Goldfields (Kalgoorlie-Norseman) area (KLCH, Kalgoorlie, and KLLS, Longshaft mine, Kambalda) contribute data. These stations are in noisy environments, and record at low gain, but some good recordings of Norseman area events have been made.

Difficulties in earthquake locations

Seismic phase arrivals from Goldfields region events, including the Norseman area, are usually very emergent at most stations in the WA seismic network. It may indicate shallow focal depth, or may be for other unknown reasons. For good location, clear P and S phases are necessary, and the emergent nature makes this difficult. When stations are closer to an earthquake, phase arrivals are often clearer, and for this reason, phase data from stations in the Goldfields area (KMBL, KLCH and KLLS) should be given extra weight in a solution.

Another difficulty is correct phase identification. At distances > 200 km, refracted phases (Pn, Sn) are predicted by models to be the first arrivals. However, since the refracted phases are of low amplitude and emergent, the later-arriving Pg (direct) phase may be misidentified as Pn arrivals.

It was possible to retrieve from archives of most of the original solutions of the EQLOCL program made by the MGO since 1991, and by GA for the period 2000 to 2009. Events since 1991 will therefore receive particular attention in this data review.

Earthquake magnitudes

The magnitudes quoted in this report are Richter magnitudes, also known as Local magnitudes (ML). As seismic instrumentation has advanced, it has been difficult to ensure that an ML values calculated in say 1960, is still equivalent to a value calculated in 2015. A major revision of methods in Western Australia occurred in 1991 (Gaull & Gregson, 1991).

2 Review of Epicentral Data near Norseman

Because of changes in earthquake location methods, and the advent of new seismic stations, the review has been subdivided into three time-periods (1970 – 1989, 1990-2009, and 2010-2018) within which data sources and location procedures are reasonably constant. In the first period locations were made manually by staff at the MGO. In the second period (1990 -2009) locations were made using the EQLOCL program, by staff at the MGO until 2000, and thereafter by AGSO (later GA) in Canberra. In the final period (2010-2018), locations were made by GA using the ANTELOPE program until 23rd May 2018, when SeisComP3 was introduced.

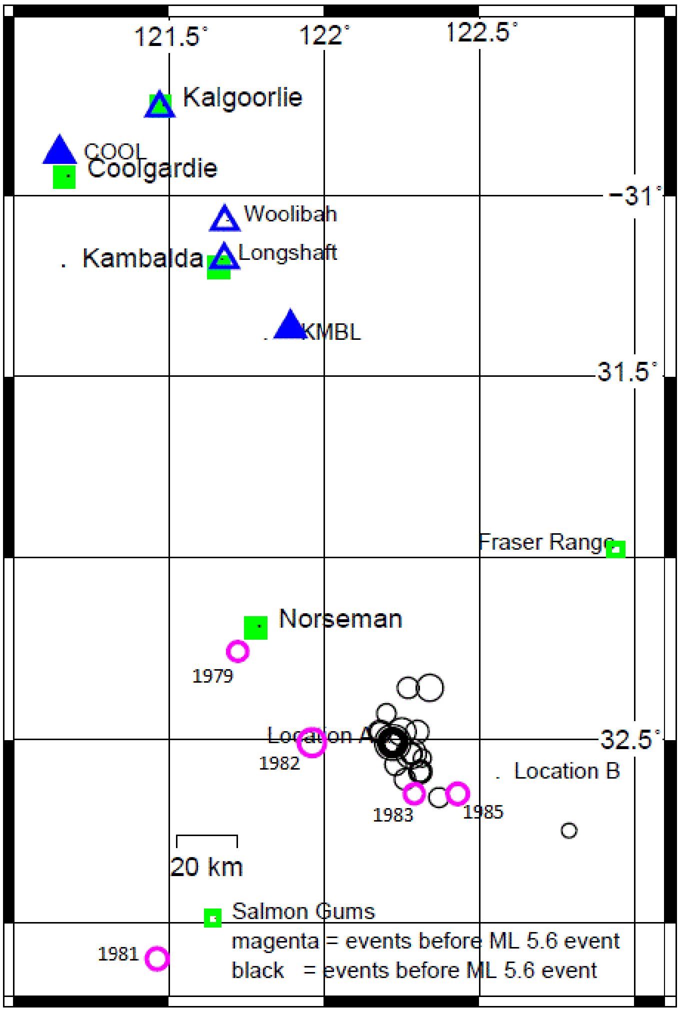

Figure 2 Seismicity of Period 1, 1970 - 1999

Period 1 (1970 -1989) Locations by the MGO using manual techniques

Because of the manual location methods employed in this period, it is considered that all of the locations have uncertainties of at least 30 km and probably more. The period is divided into two, periods A and B, with the division at the onset of the ML 5.6 event of July 1985.

Period 1A (1970 – July 1985)

There were four events near Norseman in this 15 year period (magenta circles in Figure 2), ie 1979, 1982, 1983, and the last being 5th June 1985, only 7 weeks before the ML 5 event. All of these are close enough to the ML 5.6 event of July 1985 (considering location accuracy), to be considered as precursory events to it. As indicated in the introduction, because of the limited seismic network at the time, it seems probable that there were events in the Norseman area which were not detected.

Period 1B (July1985 – Dec 1990)

The isoseismal map for the ML 5.6 event of 28 July 1985 (McCue, 1989) indicates that this event was felt at Norseman with intensity MMI V, and was felt at other locations up to 300 km distant. McCue reported that it had one foreshock and 29 aftershocks, of ML 3.0 to 4.6. Again, it is likely that there were other aftershocks which were not detected or located.

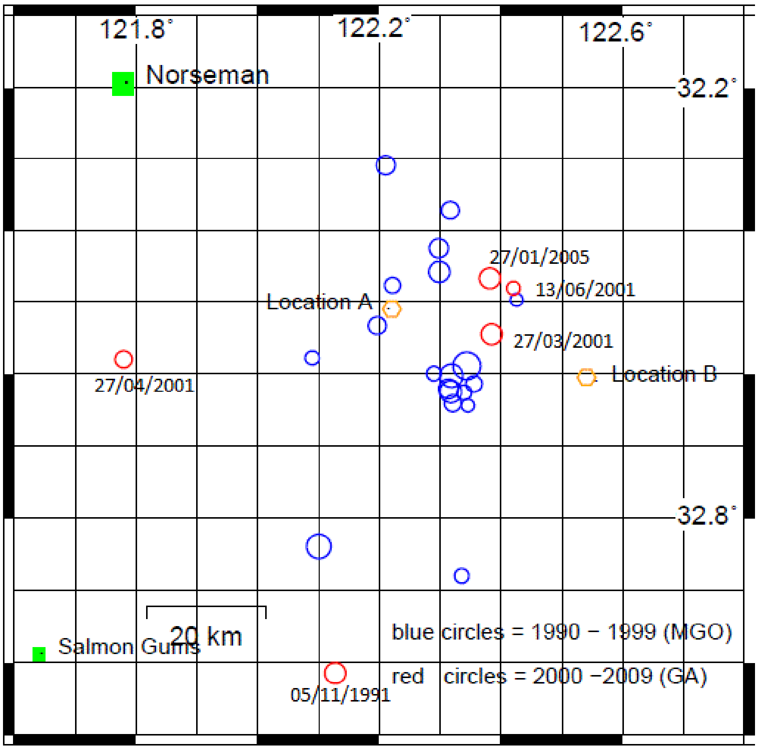

Figure 3 Seismicity in Period 2 1990 - 2009

The first 29 events in the sequence (28 July – 29 October 1985) were all given the same location (32.51°S, 122.22°E) because the analysts recognised that uncertainties in the determinations (~40 km) did not warrant separating the locations. Thereafter, locations were scattered around this central location, but location methods had not changed and the concept of giving them the same location should still have been considered. The location above is a useful reference point for the maps to be presented and will be termed Location A.

Period 2 (1991 to 2009) –Events located using EQLOCL and the WA2 model

Some of the text outputs for GA's EQLOCL solutions for the 20 events of this period are shown in Appendix 1. It shows most solutions have quite large RMS of residuals (ie, approximately 1 sec.), and the locations are therefore not good. Epicentral uncertainties of 20 km or more are likely.

Locations from Period 2 are plotted on Figure 3 in two groups. Period 2A, - blue circles on Figure 3, are locations for events between 1991 and 1999, made by the MGO. Locations in period 2B, (red circles) are locations between 2000 and 2009 made by AGSO in Canberra.

There were about 20 events in Period 2A, including two events of ML $\geq$ 4.0. The first, ML 4.2 (5 Nov. 1991), was about 30 km SSW of Location A and had no obvious aftershocks. The second, ML 4.3 (10 April 1998) had 4 aftershocks (largest ML 2.6), and they plot about 15 km to the southeast of Location A.

On 11 Oct 1994 a mag 3.9 event to occurred near Salmon Gums. This may be an unrelated event.

Period 2B 2000 – 2009

Locations were made by GA in Canberra, using basically the same methods as had been used for the 9 previous years by the MGO. There were 5 events in the period, the largest being ML 3.3 on 27 January 2005.

Period 3 2010 - 2018 events located using Antelope

In this period, locations were made by GA in Canberra using Antelope software. Initially the WA2 model was used, but from about 2015 onwards, the earth model used was IASPEI91 (Kennett & Engdahl, 1991). There were no significant changes to the seismograph network, and it is suggested that uncertainties in locations remain at about 20 km.

Because the new PSN network recorded many of the events in the period, significant events have been relocated using EQLOCL and the WA2 model. The uncertainties in the new locations are probably ~10 km.

Unfortunately, the station KMBL seems to have been out of service when the most significant activity was occurring in mid 2016. This means that location uncertainties would be about double of what they would otherwise have been (ie, ~40 km).

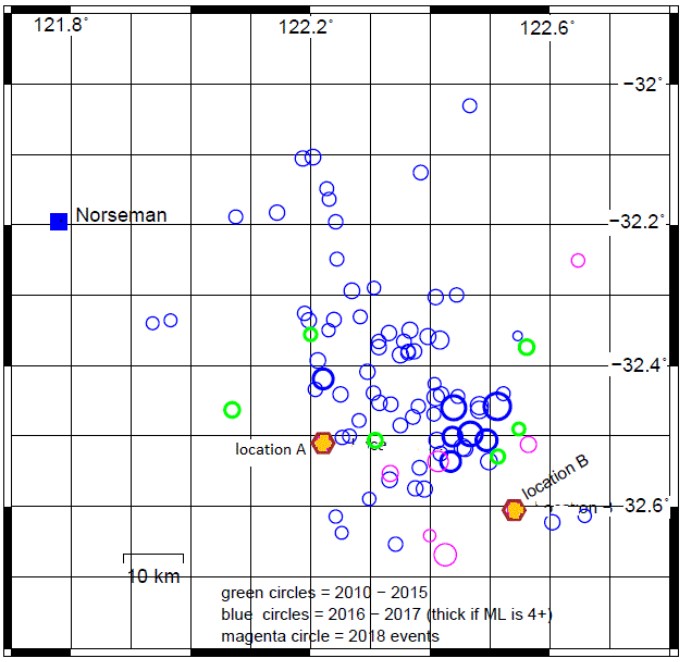

Figure 4 Seismicity in Period 3 2010 – 2018

Period 3A 2010 – April 2016

Nine events were located by GA (green circles on Figure 4 - largest ML 3.4, 14 Dec 2011). The locations are relatively scattered, and Figure 4 suggests no discernible difference from the more numerous events of sub-period B.

Importantly, one of the events (16 Nov 2014, ML 2.5) was also recorded on the ANU temporary network. Waveform data for this event was supplied by Michelle Salmon. A very good location for the event has been achieved (Figure 6), which plots about 15 km southeast of Location A. The nearest three ANU stations are shown in the figure. The uncertainties in latitude and longitude are estimated to be less than 2 km. This location is defined here as Location B, and considering the uncertainties of the other locations, could represent the true location for most of the events located in this region south-east of Norseman.

Depths are difficult to determine accurately, and the computed values are model-dependent. The depth of this event is unclear. Using only the closer stations gives a depth of the order of 7 to 11 km., while including more distant stations results in a shallower depth. However the closest recording station is 35km away, therefore computed depths of less than 20km are not considered to be reliable.

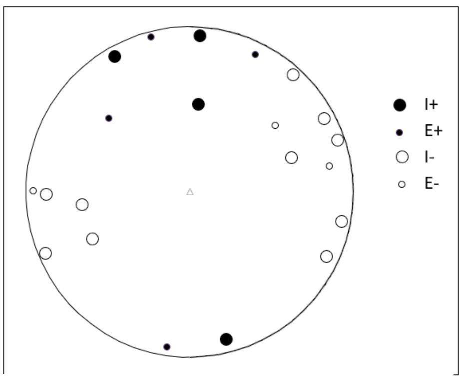

Figure 5 Partial focal mechanism 2014-11-16 event

There were good first motion recordings on a sufficient number of ANU stations to produce a partial focal mechanism (Figure 5). Unfortunately the depth and model uncertainties affect the focal mechanism. Regardless of the depth, the direction of compression is clearly east-west. It is not clear whether the faulting was normal, strike-slip or thrust. This is different from the mechanism of the 1985 event by McCue (1989).

Period 3B May 2016 – Oct. 2018

Distribution in time

This period began with the ML 5.0 at 1530 UT on 28 May 2016. It was followed an hour later (1638 UTC) by a ML 5.1 event. Another 15 GA located events occurred in the following six weeks, before a ML 5.6 event on 08 July 2016. The largest was ML 4.4 on 08 June 2016, and the others ranged between ML 2.9 and ML 3.8.

The ML 5.6 event on 08 July 2016 was followed by another

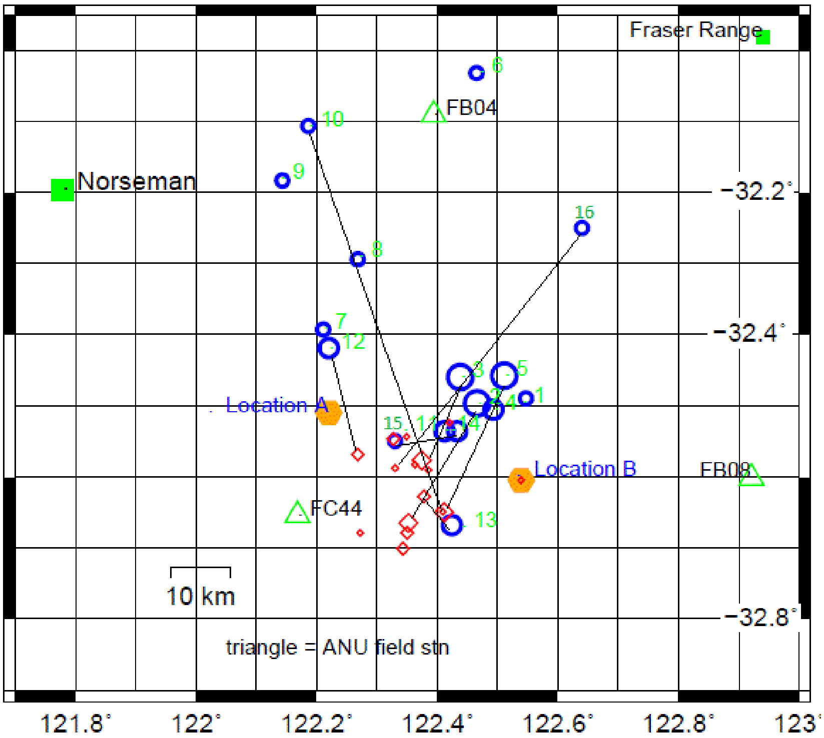

Figure 6 Earthquake relocations near Norseman, 2016 – 2018

Table 1 Relocations of selected events in Period 3 (2010 – 2018)

Date	evt #	ml	Revised soln (a) Latit.	Longit	rms sec	dep km	GA soln. (b) Latit.	Long	rms sec	dist a-b	comment
30 Sep 2013		3.7	31.893	121.42	.38	2n*	31.898	121.498	.87	7	NE of Norseman
16 Nov 2014	1	2.5	32.605	122.539	.05	6.5	32.490	122.547	.58	13	**Uses ANU data**
2016											
28 May 1530	2	5.0	32.665	122.352	1.1	0.9	32.497	122.466	1.0	26	
28 May 1638	3	5.1	32.574	122.377	.50	7	32.460	122.438	1.0	15	
08 June 0201	4	4.4	32.701	122.343	.85	10.4	32.506	122.493	.85	27	
08 July 0940	5	5.6	32.65	122.411	.37	2n	32.458	122.511	.70	23	
08 July 1030	6	2.9	32.524	122.42	.47	2n	32.031	122.465	.45	55	
08 July 1431	7	3.3	32.544	122.349	.51	3.6	32.393	122.211	1.1	21	
09 July 1139	8	3.3	32.583	122.363	.52	2n	32.294	122.268	.71	33	
09 July 1353	9	3.2	32.679	122.272	.45	6.4	32.183	122.143	.77	57	Far north
09 July 1502	10	3.2	32.649	122.409	.63	2n	32.106	122.186	.66	64	
14 Jul 1008	11	4.2	32.679	122.350	.25	10.1	32.536	122.433	.77	17	
05 Sep 1623	12	4.3	32.568	122.268	.29	1.1	32.419	122.220	.98	17	
2018											
20 Jun 2018	13	4.7	32.628	122.378	.16	6.8	32.668	122.424!!	.78	6	
08 Aug 2018	14	4.3	32.547	122.327	.33	10.9	32.536	122.412!!	1.1	6	
12 Oct 2018	15	3.4	32.591	122.385	.50	2.7	32.553	122.332!!	0.8	5	
13 Oct 2018	16	2.8	32.588	122.330	.30	3.0	32.251	122.646!!	0.5	40	

* "n" indicates solution constrained to the depth indicated. (note - all GA solns assigned a depth of 10 km)

!! indicates event located by GA using seiscomP3

14 events on the same day (largest ML 3.3) and another three on the day following. There were three ML 4+ aftershocks -14 July (ML 4.2), 16 July (ML 4.0), and 9 September (ML 4.2). The plot of aftershocks shows a scattered distribution, and the 9 Sept event is well to the northwest of the group. Scattered aftershocks continued into 2017.

Examination of recordings from the PSN stations KLCH and KLLS shows many additional small aftershocks for the 2016 events. One of the larger of these was an event of ML 2.5 at 1656 on 28 May. That is in the hour between the two ML 5 events.

Two magnitude 4+ events occurred in mid-2018 (20th June, ML 4.7, and 8th Aug., ML 4.3, events 13 and 14 in Table 1), were located by GA using a new program, Seiscomp3. The larger was well to the south of most of the other GA locations. Relocations of these two events resulted in relatively small shifts westwards, suggesting that the original solutions had been improved because they used data from the KMBL station. Two smaller events (ML 3.4 and 2.8) occurred in October 2018, the larger of which was near the August 2018 location. The smaller event (event 16, Table 1)was located about 40 km to the northeast, but its relocation brings it much closer to the other events. Note that about a dozen small aftershocks of the ML 4.7 event were recorded on the sensitive PSN station BR4 (Bonnie Rock) but were undetected, or at least not located, by the GA network.

Geographic distribution

The GA locations of most of the larger events of 2016 plot about 20-30 km east of Location A. These locations were made without the assistance of what would have been the nearest station, KMBL, as it seems to have been out of service for much of 2016.

The smaller events (ML ~ 3) are quite scattered, as might be expected, as they will have fewer arrivals, which are also likely to be of poor quality. Fourteen of the events near Norseman (labelled 1-14 in Table 1) have been relocated, with the assistance of PSN stations near Kalgoorlie. These relocations result in shifts of ~ 20km to the SSW (figure 5). However, the relocations of some of the smaller events, to the north and northwest of the main group, move them 50 – 60 km southwards to join the main group. These locations are, in general, about midway between locations A and B, and a possible north-south trend could be interpreted. This is vague however, and perhaps location B could be the correct central location of the group, with the offset being due to bias introduced by the earth model used (WA2).

3 Discussion

This report has attempted to demonstrate that the large scatter of the epicentres near Norseman is not real, and that epicentral uncertainties have concealed the possibility that all of the events in the area in the nearly 50 years reviewed have come from a single source location. This location is suggested to be at the relocated position (location B) of a relatively small event (ML 2.5) which was well-determined using data from a temporary ANU network which surrounded it.

If this one source zone is responsible for 4 events of magnitude 5.0 to 5.6 events, then there may be a ruptured area of approximately 100 sq km, possibly stretching over a length of 15 km.

The locations of some recent West Australian events (eg, Kalannie, 2005 and Broomehill, 2007) have been precisely determined using satellite (InSAR) data (Dawson et al., 2008), and the technique was tried on the Norseman 2016 events, but a null-result was obtained, possibly indicating that the events were relatively deep (S. Lawrie, pers. comm., 2018). On the other hand, extended aftershock sequences normally only occur with shallow or surface rupturing events. This perhaps suggests a shallow source for the activity.

If we are correct in our proposition that the activity from 1970 to 2018 is mostly coming from a single small source zone, it indicates a similarity with the South West Seismic Zone where small source zones appear to account for most of the activity, and a single zone may have significant events separated by many years. Examples are Bonnie Rock where magnitude 4 events occurred in 1994 and 2017, north of Corrigin, where an ML 3.5 events occurred in 1988 and an ML 3.3 in 2017 (Dent, 2017), and Meckering where major events occurred in 1968 and 1989. There may be many point sources of seismicity in south WA at which seismicity recurs at intervals, and this may have been occurring at these points for hundreds of years, or even an order of magnitude longer. As seismicity in Australia has only been monitored in any detail for about 60 years, these data are too few to estimate recurrence intervals. The continuing nature of this source is shown in figure 7.

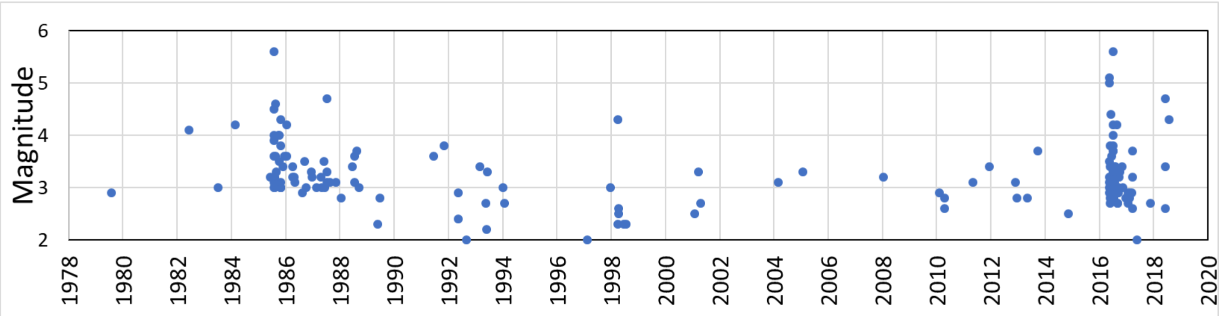

Figure 7 Time sequence of Norseman activity

4 Conclusions

The two events before the May 2016 ML 5.0 event (one occurring a year before) may be foreshocks of that event. Following the ML 5.6 event of 1985, magnitude 4+ events have occurred intermittently (1998, 2016, 2018), most notably the ML 5.0, 5.1 and 5.6 events in May and July, 2016. Individual magnitude 4+ events appear to have their own sequences of aftershocks - the larger the event, the larger the aftershock sequence. Because of the remoteness of the region, only the larger aftershocks may be located. All events may come from the same location.

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Appendix 1 : Some of GA's EQLOCL solutions for Norseman events

```
Date             2001-02-02          Origin Time    0833 12.60   +-   8.93
Zone                     51
Easting              504.87   +-  17.30              Longitude     123.052
Northing            6452.18   +-  32.18              Latitude      -32.067
Depth                 10.00   +-  62.97  G

Arrival times    =  9           S.D. = 1.207        Seismographs =  6
Nearest recorder =  134.5 km    Gap  = 166.9 deg    Accuracy = H
Effects Code     =              Imax =  0           Fault =

  60 km  N ( 11 deg) of  FB08
WESTERN AUSTRALIA
 680 km  E ( 93 deg) of PERTH
 121 km  E ( 83 deg) of NORSEMAN

Assign ML  2.5

DATA USED
Code  Wave        AT     +-    WT      CT      DT     Dist  Azim    Ad    Ae
KMBL e P       33.90   0.10  0.86   33.81   0.09   134.5   304  -30.8  30.8
KMBL e S       49.00   0.10  0.77   49.74  -0.74   134.5   304  -23.9  23.9
FORT e P       77.90   0.10  0.76   78.20  -0.30   496.6    74  -42.2  42.2
FORT e S      127.20   0.10  0.68  127.06   0.14   496.6    74  -40.3  40.3
KLBR e P       80.20   0.10  0.76   79.17   1.03   504.5   274  -42.2  42.2
KLBR e S      130.90   0.10  0.68  128.75   2.15   504.5   274  -40.3  40.3
RKGY e S      153.40   0.10  0.67  155.65  -2.25   632.3   241  -40.3  40.3
MEEK e S      177.30   0.10  0.66  178.41  -1.11   740.2   323  -40.3  40.3
MORW e P      109.70   0.10  0.73  109.01   0.69   751.3   294  -42.2  42.2
                         9 times used, S = 1.207
Deferred Data
BLDU e P       88.30   0.10  0.74   93.79  -5.49   625.3   283  -42.2  42.2
BLDU e S      149.90   0.10  0.67  154.19  -4.29   625.3   283  -40.3  40.3
RKGY e P       89.40   0.10  0.74   94.62  -5.22   632.3   241  -42.2  42.2
MEEK e P      106.20   0.10  0.73  107.70  -1.50   740.2   323  -42.2  42.2
MORW e S      178.80   0.10  0.66  180.70  -1.90   751.3   294  -40.3  40.3


Date             2001-03-27           Origin Time    0458 47.15   +-   2.32
Zone                     51
Easting              442.17   +-   5.55              Longitude     122.384
Northing            6399.01   +-   9.38              Latitude      -32.545
Depth                  9.69   +-  17.37

Arrival times    = 12           S.D. = 0.445        Seismographs =  7
Nearest recorder =  138.5 km    Gap  = 202.9 deg    Accuracy = C
Effects Code     =              Imax =  0           Fault =

  23 km NE ( 59 deg) of  FC44
WESTERN AUSTRALIA
 619 km  E ( 98 deg) of PERTH
  69 km SE (124 deg) of NORSEMAN

Assign ML  3.3

DATA USED
Code  Wave        AT     +-    WT      CT      DT     Dist  Azim    Ad    Ae
KMBL i+P       69.20   0.10  1.23   68.95   0.25   138.5   340  -30.8  30.8
```

KMBL e S	85.10	0.10	0.77	85.34	-0.24	138.5	340	-23.9	23.9
KLBR e P	107.40	0.10	0.77	107.18	0.22	450.0	282	-42.2	42.2
KLBR e S	151.60	0.10	0.69	151.90	-0.30	450.0	282	-40.3	40.3
FORT e P	121.40	0.10	0.75	121.92	-0.52	572.1	71	-42.2	42.2
FORT e S	177.90	0.10	0.68	177.56	0.34	572.1	71	-40.3	40.3
BLDU e P	121.90	0.10	0.75	122.94	-1.04	580.4	290	-42.2	42.2
BLDU e S	179.70	0.10	0.67	179.34	0.36	580.4	290	-40.3	40.3
MUN e P	124.20	0.10	0.75	123.62	0.58	586.1	274	-42.2	42.2
MORW e P	140.00	0.10	0.73	139.84	0.16	720.2	300	-42.2	42.2
MORW e S	208.70	0.10	0.66	208.77	-0.07	720.2	300	-40.3	40.3
MEEK e P	143.40	0.10	0.73	143.47	-0.07	749.9	330	-42.2	42.2

12 times used, S = 0.445

Deferred Data

MUN e S	178.20	0.10	0.67	180.53	-2.33	586.1	274	-40.3	40.3
MEEK e S	213.50	0.10	0.66	215.07	-1.57	749.9	330	-40.3	40.3

Date 2001-04-27 Origin Time 1423 58.85 +- 5.90

Zone 51

Easting 385.38 +- 14.96 Longitude 121.779

Northing 6394.65 +- 22.01 Latitude -32.580

Depth 10.00 +- 56.11 G

Arrival times = 10 S.D. = 0.824 Seismographs = 7

Nearest recorder = 395.7 km Gap = 168.5 deg Accuracy = E

Effects Code = Imax = 0 Fault =

37 km W (282 deg) of FC44

WESTERN AUSTRALIA

563 km E (99 deg) of PERTH

42 km S (180 deg) of NORSEMAN

Assign ML 2.7

DATA USED

Code Wave	AT	+-	WT	CT	DT	Dist	Azim	Ad	Ae
KLBR e P	111.40	0.10	0.78	112.27	-0.87	395.7	285	-42.2	42.2
KLBR e S	153.30	0.10	0.70	152.10	1.20	395.7	285	-40.3	40.3
RKGY e P	125.00	0.10	0.76	124.86	0.14	499.8	241	-42.2	42.2
RKGY e S	174.50	0.10	0.68	174.02	0.48	499.8	241	-40.3	40.3
BLDU e P	126.80	0.10	0.76	128.39	-1.59	529.0	293	-42.2	42.2
MUN e S	180.10	0.10	0.68	180.32	-0.22	529.8	275	-40.3	40.3
FORT e P	140.80	0.10	0.74	140.27	0.53	627.4	73	-42.2	42.2
MORW e P	145.70	0.10	0.74	145.95	-0.25	674.2	303	-42.2	42.2
MORW e S	211.40	0.10	0.66	210.74	0.66	674.2	303	-40.3	40.3
MEEK e P	152.70	0.10	0.73	152.33	0.37	726.8	334	-42.2	42.2

10 times used, S = 0.824

Deferred Data

BLDU e S	183.30	0.10	0.68	180.16	3.14	529.0	293	-40.3	40.3
MUN e P	133.50	0.10	0.76	128.48	5.02	529.8	275	-42.2	42.2
FORT e S	204.00	0.10	0.67	200.86	3.14	627.4	73	-40.3	40.3
MEEK e S	224.30	0.10	0.66	221.84	2.46	726.8	334	-40.3	40.3