Seismicity in 2019 in the Great Southern region of Western Australia

Vic Dent[1] & David Love [2]

1. University Associate, Curtin University, Perth, W.A.; Honorary Research Associate, The UWA Institute of Agriculture, UWA Perth: Email: vic_dent@yahoo.com
2. Seismological Association of Australia, Adelaide, South Australia; Email: david@earthquake.net.au

Abstract

Much of the seismicity in southwest WA occurs in localised groups of recurring earthquakes, or clusters. Four potential cluster sites have been identified in the Great Southern Region of WA in the period January to November 2019. A group near Newdegate contained the largest event of the year (ML 4.3), and it is suggested these events belong to an earthquake group first identified in 2016. The three other groups identified are near Denmark, Gnowangerup and Ongerup. Relocations of many of the events using the VIC5A earth model suggests tighter groupings for the events than the published Geoscience Australia locations. The Gnowangerup and Ongerup groups are also close spatially, and there may be a causal link between the groups. The region has been categorised as a region of relatively low seismicity, and the higher numbers of events in 2019 may be related to the occurrence of two ML 5 event in Lake Muir in late 2018.

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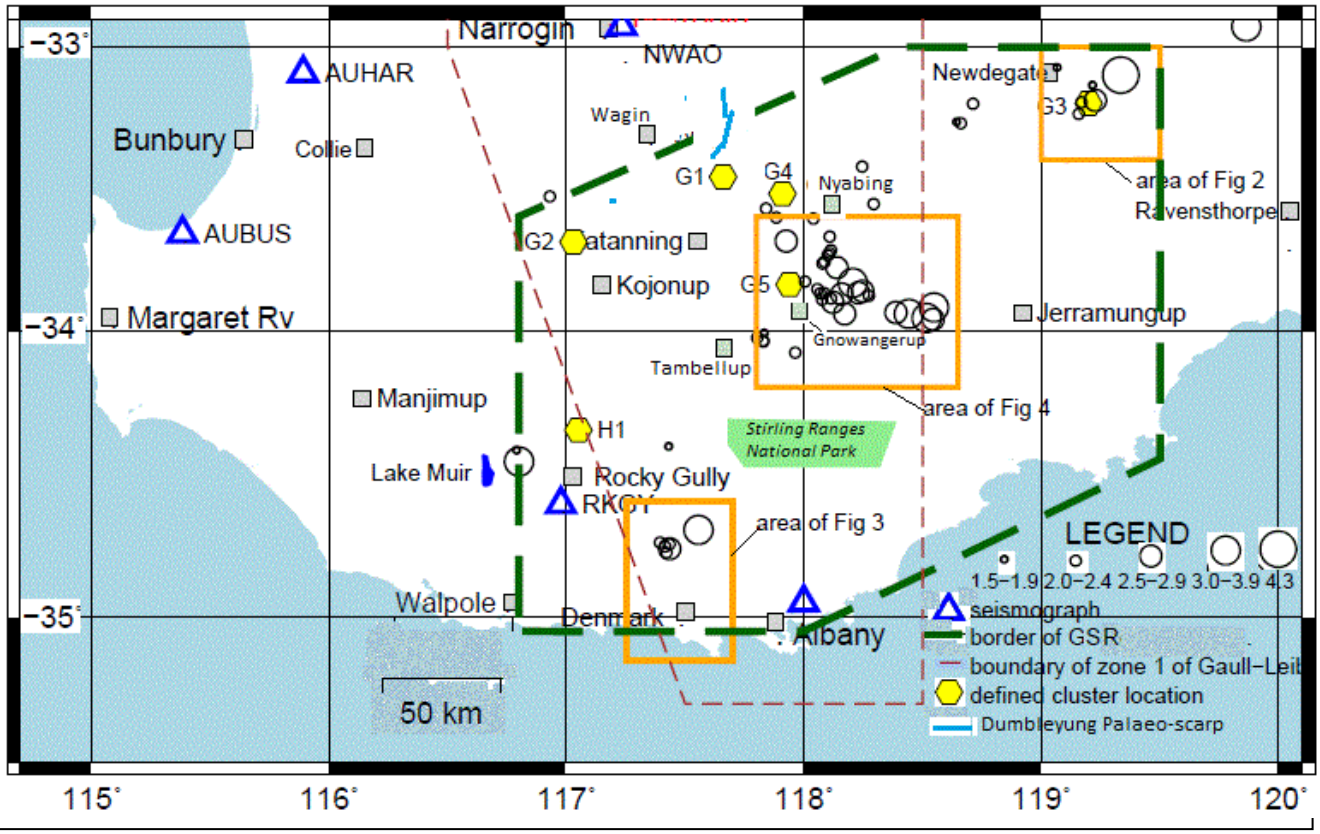
1 Introduction

The Great Southern region of Western Australia (GSR) is an important agricultural area, in the southern part of the WA wheatbelt. The principal towns are Albany and Katanning. It also constitutes the southern region of the southwest seismic zone (SWSZ), defined by Doyle (1971), and in the vicinity of "seismic zone 1" of Gaull & Leiba (1987). This region is considered generally less seismically active than the region to the north (Gaull & Leiba's "zone 2"), which includes the Meckering and Cadoux regions. However two ML 5 events were recorded

Figure 1 Events in The Great Southern region of WA, ML ≥ 1.8, Jan. 2017- Nov. 2019



near Lake Muir (Figure 1) in September and November 2018, and about 800 (mostly ML < 1.5) aftershocks were recorded by Geoscience Australia (GA) up to February 2019 (Clark et al., 2019).

GA's Neotectonic Features Database shows four probable neotectonic fault scarps in the region, of which the best defined is a 36 km long scarp south-west of Dumbleyung (Figure 1). Clark (2010) suggests the most recent movement on this scarp was about 8,000 years ago. Other scarps in the region are near Katanning, Tambellup and Nyabing.

Table 1 Cluster locations previously identified in the Great Southern Region

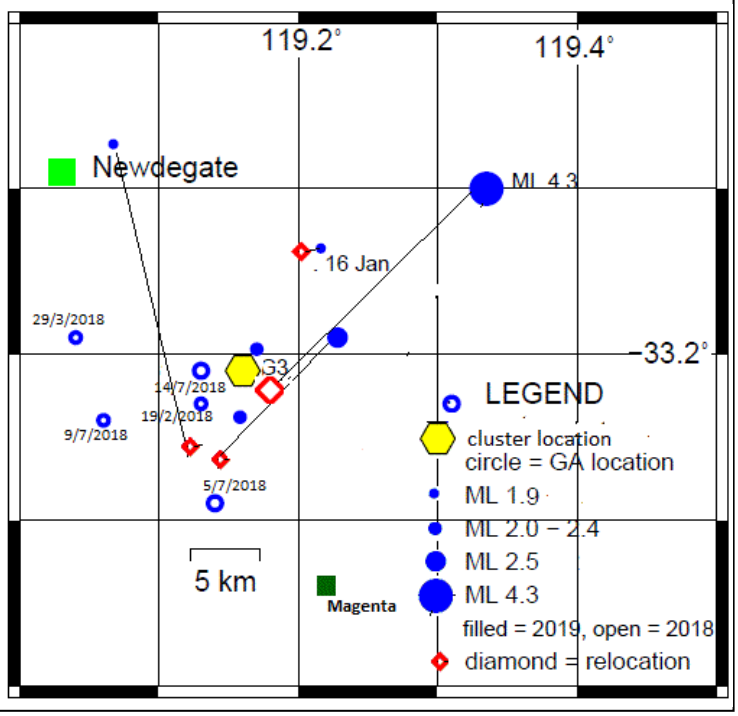
ID	location	Latitude	Longitude	Largest event	Previous ID*
G1	S of Dumbleyung	-33.46	117.66	ML 2.9 (July 2013)	S
G2	N of Kojonup	-33.69	117.03	ML 3.5 (Oct 2011)	Theta
G3	SE of Newdegate	-34.23	119.16	ML 4.3 (July 2019)	Tau
G4	West of Nyabing	-33.50	117.92	ML 2.9 (Dec 2015)	Sigma
G5	NW of Gnowangerup	-33.84	117.94	ML 2.4 (Apr 2013)	
H1	N of Rocky Gully	-34.35	117.05	ML 2.9 (June 2013)	T

* . Indicates ID used in Dent (2016)

Much of the seismicity in the SWSZ occurs in localised clusters. Dent (2016) has suggested there are about 60 cluster locations which have been active in the SWSZ over the last ~10 years. They have been labelled according to the zone they occur in, and the zones are based on latitude. Zones A to F are between 30 and 33 degrees south. Zone G is 33-34 degrees south, and zone H is 34 to 35 degrees south. Five cluster locations have so far been identified in zone G and one in zone H, as shown in Table 1, and plotted on Figure 1. These locations are the assumed centres of reasonably well-defined groups of earthquakes in the past 6 years, and it is suggested that the locations may also be the focus of future activity.

The 2019 seismicity of the GSR is shown in Figure 1. It shows 7 events of ML 3.0 and above. Four probable cluster groupings evident in this plot will be described in more detail below. They are (1) near Newdegate, (2) north of Denmark, (3) northeast of Gnowangerup, and (4) north of Ongerup. Other smaller cluster groups could also be present. Many of the 2019 events in the GSR have been relocated. The relocations use the VIC5A earth model, and generally include some new data from the "Public Seismic Network" or PSN (Dent, 2013). A number of PSN stations have operated near Gnowangerup since 2008, and GNOT (in the town), opened January 2017, has contributed data to many of the relocations. A "seismometers in schools" seismograph (Balfour et al., 2013) at Albany (AUALB), installed in 2012, also contributes some useful data.

Figure 2 Events near Newdegate and their relocations



2.1 Southeast of Newdegate

Dent (2016) defined a cluster location in the vicinity of Newdegate (G3) , based on a group of events in June 2015. The largest event in this group was ML 2.8.

The largest event in the area in 2019 was an ML 4.3 event on 20 June (Figure 2). There are five other events near this event (four on 20 June and a small event on 16 Jan). The relocation of four of the events (Table 2) moves them by up to 20 km, and closer to cluster centre G3. The ML 4.3 event moves to within 2 km of G3.

Table 2 Locations/relocations of events near Newdegate and Denmark, 2019

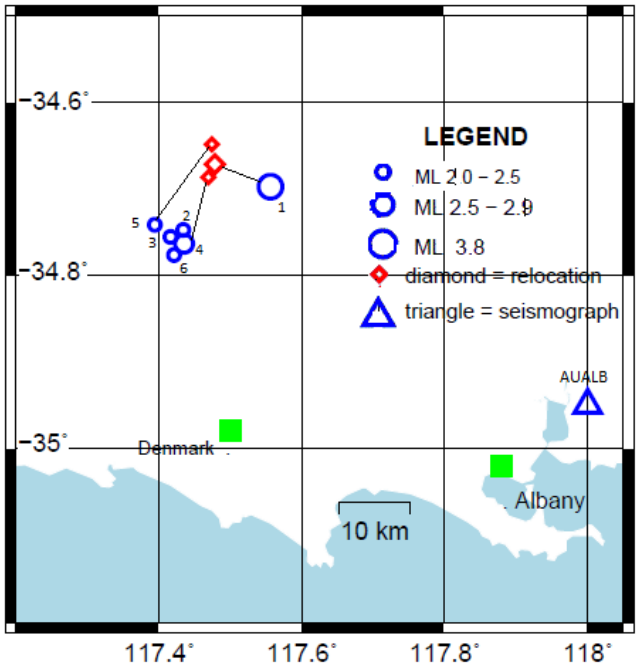
Ref #	Date/Time	GA location		ML	Phases /stns	Rms (sec)	Region	Relocation		Depth (km)	Phases /stns	Rms (sec)
		Lat	Lon					Lat	Lon			
	16/1 1404	-33.14	119.22	1.9	8/5	0.28	Newdegate	-33.14	119.20	9.9	10/8	0.10
	20/6 0655	-33.24	119.16	2.3	7/4	0.40	Newdegate					
	20/6 1430	-33.10	119.33	4.3	27/19	1.04	Newdegate	-33.21	119.19	9.5	10/7	0.18
	20/6 1441	-33.19	119.23	2.5	12/7	1.12	Newdegate	-33.26	119.14	2.3	11/7	0.23
	20/6 1511	-33.07	119.07	1.9	5/3	0.75	Newdegate	-33.25	119.12	5.9	5/3	0.19
	20/6 1547	-33.20	119.17	2.1	7/4	0.78	Newdegate					
1	01/8 1649	-34.70	117.56	3.8	19/27	1.10	Denmark	-34.67	117.48	4.1	9/7	0.14
2	06/8 2006	-34.76	117.42	2.3	4/8	0.69	Denmark					
3	23/8 2151	-34.75	117.43	2.2	6/10	0.47	Denmark					
4	31/8 0556	-34.76	117.43	2.8	8/13	0.58	Denmark	-34.69	117.47	8.5	9/5	0.13
5	09/9 0853	-34.74	117.39	2.5	7/10	0.52	Denmark	-34.65	117.47	2.0	5/3	0.20
6	13/9 1232	-34.78	117.42	2.1	5/10	0.78	Denmark					
Ref # - refers to Figure 3												

In 2018 six events occurred in the area of the 2019 activity (3 in July 2018, including the largest, ML 2.8). It seems likely that the 2018 and 2019 events represent continuing activity at this cluster centre, but the ML 4.3 of July 2019 is clearly the largest event in at least four years of activity.

2.2 North of Denmark

There are six events in this group, between 01 Aug and 13 Sept 2019 (Figure 3 and Table 2). The largest event (ML 3.8) was the initial event, and the following four occurred over the following 5 weeks. The GA location of the main event seems remote from the next five, but it has a high RMS of residuals (Table 2). GA assigned a depth of 10 km to all events. Three of the events in the group have been relocated (using the VIC5A model), and it seems to bring the main event closer to the following events, and moves it about 10 km north. A common location is suggested at 34.67°S, 117.48°E The largest event has a depth of 8 km and the RMS of residuals is low, suggesting it is a good location. These were the first events recorded in the Denmark area for at least 20 years.

Figure 3 Events near Denmark, and their relocations. Event numbers refer to Table 2.



2.3 Northeast of Gnowangerup

There are 22 events in this group (Figures 4, 5 and 6, & Table 3), most of which have been relocated. Relocations which have GNOT data can be expected to be more accurate. Most events are between February and March 2019, although the first event was 31 Dec 2018. There was one magnitude 3 event, on 11 March 2019 (ML 3.5).

The GA locations are quite scattered – over about 40 km., but the relocations (Figures 4 and 5) suggest a tighter grouping. Relocation of the main event (ML 3.5) moves it about 10 km westwards, and closer to other events in the group. A possible northwest trend to the events could be suggested, but with a probable epicentral uncertainties of at least +/-5 km, this trend is speculative. Note that trends can be introduced by poor azimuthal distribution of the recording seismographs.

A common location for the group is suggested at 33.87ºS, 118.10ºE, close to the relocated position of the main event.

Figure 4 Events near Gnowangerup and Ongerup, and their relocations. Event numbers near Ongerup refer to Table 3.

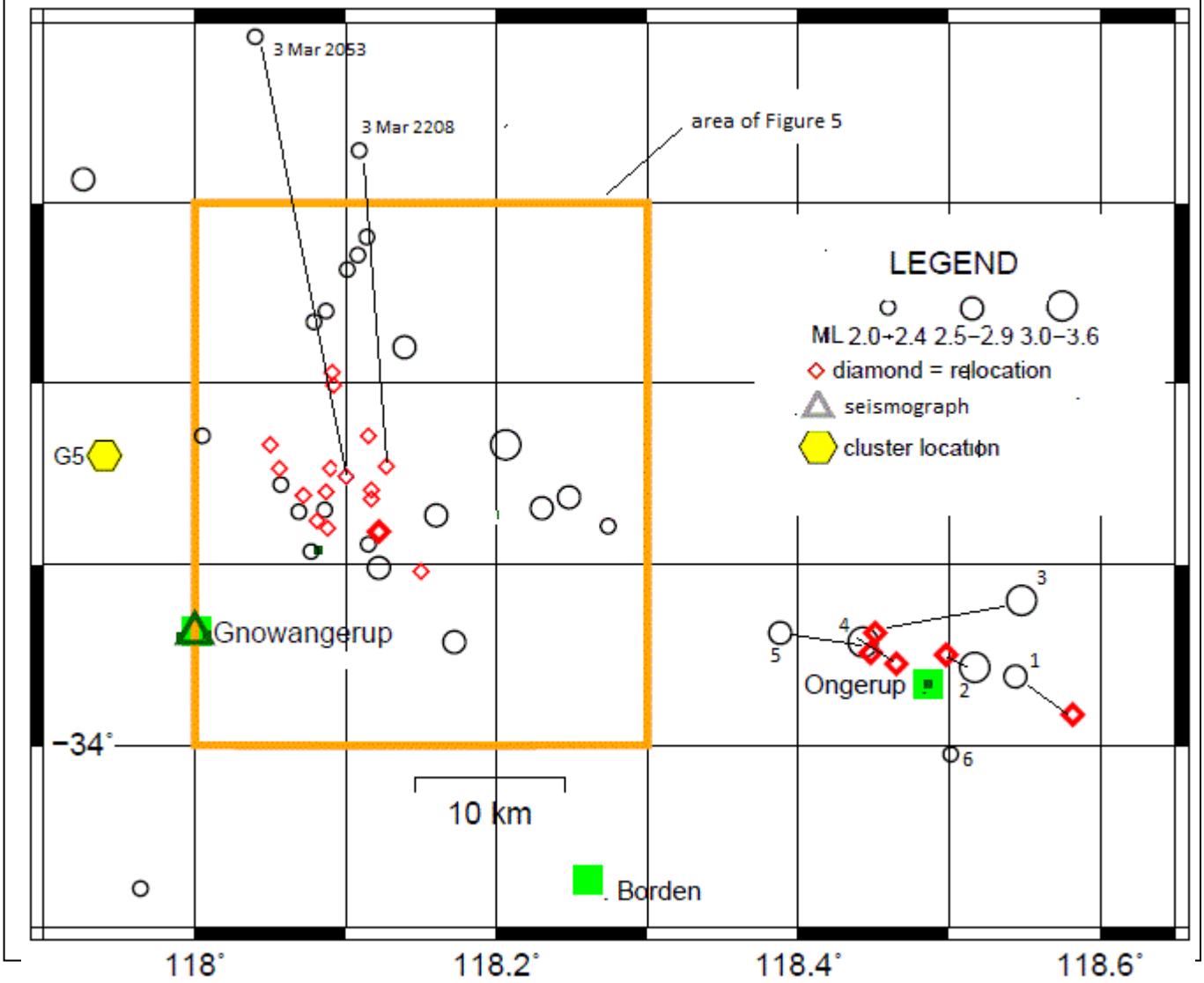
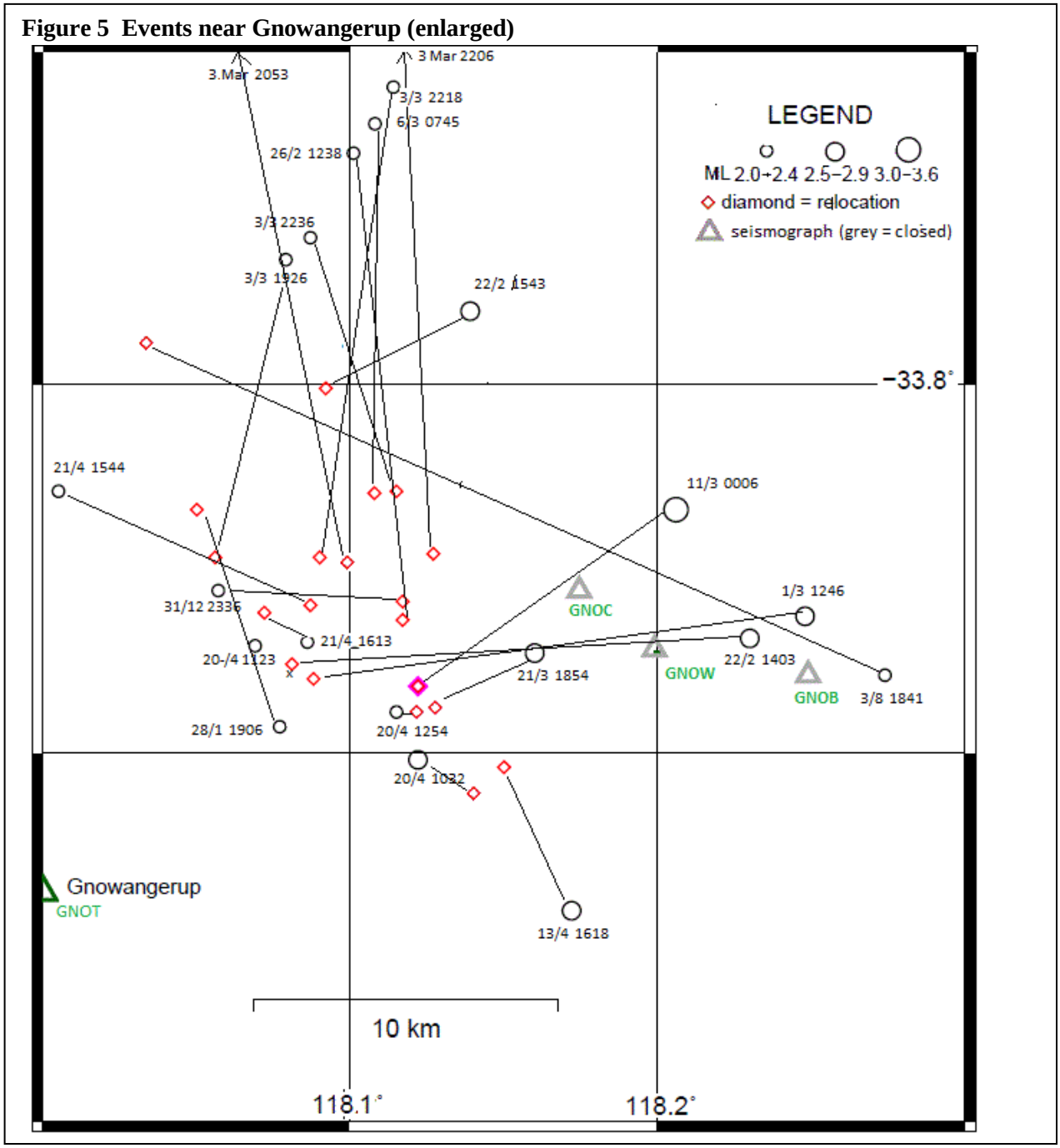


Figure 5 Events near Gnowangerup (enlarged)



2.4 North of Ongerup There are six events in this group (Figures 4 and Table 3). The activity appearing to begin in November 2018 with an ML 2.7 event, and continuing until at least August 2019. The largest event was ML 3.6 on 13 January 2019, and there were two other ML 3 events. Relocations bring them closer together. The probable location seems to be about 4 km northwest of Ongerup, the suggested coordinates being 33.96ºS, 118.47ºE.

Note that the Ongerup events are “swarm-like” (ie, the largest event is not at the beginning). Note also that there were more ML 3 events than ML 2 events. They are also relatively ‘spread-out” over 2019.

Table 3 Locations/ relocations, of events near Gnowangerup and Ongerup, 2019

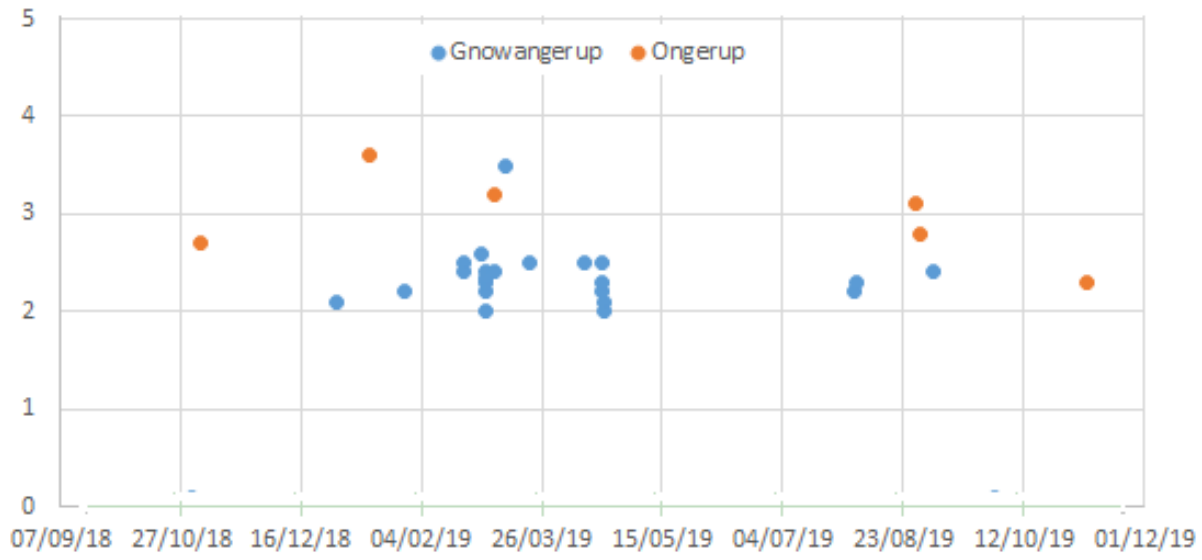
Ref #	Date/time	GA location*		Mag	Region	relocation		dep	Rms	
		Lat.	Long.	ML		Latitude	Longitude	Km	sec	
1	04/11/18 1348	33.96	118.54	2.7	Ongerup	-33.983	118.582	15.3	.144	
	31/12/18 2336	33.86	118.06	2.1		-33.859	118.117	11.4	.110	
2	13/01/19 1943	33.96	118.52	3.6	Ongerup	-33.950	118.498	14.8	.144	
	28/01/19 0647	33.89	118.08	2.2		-33.834	118.050	4.1	.172	Closest stn LM01
	22/02/19 1403	33.87	118.23	2.5		-33.876	118.081	7.2	.252	
	22/02/19 1543	33.78	118.14	2.5		-33.801	118.092	7.7	.367	
	26/02/19 1238	33.74	118.19	2.2		-33.867	118.121	2.6	.09	No stns to sth
	01/03/19 1246	33.86	118.25	2.6		-33.880	118.088	4.4	.18	
	03/03/19 1926	33.77	118.08	2.2		-33.847	118.056	11.3	.37	
	03/03/19 2053	33.61	118.04	2.3		-33.848	118.100	9.3	.212	big move south
	03/03/19 2206	33.67	118.11	2.4		-33.846	118.127	0.8	.09	big move south
	03/03/19 2236	33.76	118.09	2.0		-33.829	118.115	2.2	.11	
	03/03/19 2218	33.72	118.11	2.3		-33.847	118.090	4.3	.16	
3	6/03/19 0659	33.92	118.55	3.2	Ongerup	-33.949	118.448	2.9	.49	
	06/03/19 0745	33.73	118.11	2.4						
	11/03/19 0006	33.83	118.21	3.5	Gnowang.	-33.864	118.117	9.5	.094	
	21/03/19 1854	33.87	118.16	2.5		-33.882	118.122	5.8	.189	
	13/04/19 1618	33.94	118.17	2.5		-33.904	118.150	7.3	.255	
	20/04/19 1032	33.90	118.12	2.5		-33.910	118.141	10.9	.096	
	20/04/19 1123	33.87	118.07	2.3		-33.871	118.081	9.6	.126	
	20/04/19 1254	33.89	118.12	2.3		-33.889	118.115	11.7	.094	
	21/04/19 1544	33.83	118.01	2.1		-33.860	118.087	9.5	.191	
	21/04/19 1613	33.87	118.09	2.0		-33.862	118.072	10.6	.134	
4	28/8/19 0204	33.94	118.44	3.1	Ongerup	-33.955	118.465	15.2	.059	
	03/08/19 1841	33.88	118.27	2.2						
5	30/08/19 0054	33.94	118.39	2.8	Ongerup	-33.938	118.451	7.4	.118	
	06/09/19 0734	33.69	117.93	2.5		-33.703	117.983	10.2	.227	
6	07/11/19 0124	34.00	118.51	2.3	Ongerup					

2.5 Other historical activity in the area of Figure 4

Cluster location G5 was named in Dent (2017) on the basis of an ML 2.4 event in April 2014, and about 20 small events (max ~ ML 1.5) recorded by the seismograph GNOC in August 2016. It is about 10 km west of the 2019 activity, and its estimated uncertainty is about +/- 5 km.

A cluster of small events (largest ML 2.3) was recorded by a temporary network around the seismograph ONG1 between November 1990 and March 1991 (Dent, 2008). Another cluster of small events (largest ML 2.3) occurred in the vicinity of the seismograph GNOW between November 2007 and March 2008 (Dent, 2008). Only two of these events were recorded by the GA network, but many hundreds of smaller ones were felt at the location of GNOW.

Figure 5 Time vs Magnitude plot for events near Gnowangerup and Ongerup



3 Discussion

Note that, besides being relatively close spatially (ie, about 30 km apart), the Gnowangerup and Ongerup groups are roughly contemporaneous, suggesting a connection between the two groups. Contemporaneous activity in two neighbouring cluster groups has been noted before in the SWSZ, eg. activity at clusters west of Beacon and north of Koorda in 2012, and north of Hyden and north of Holt Rock in 2013 (Dent & Collins, 2018).

The Newdegate sequence demonstrates clusters can be active over several years at least. As these events are "recent" (all in 2019), it is likely that more events near these locations may be noted in 2020 and probably onwards. Better locations of future events may allow refinement of the suggested "common locations".

As noted earlier, the relocations presented here were made using the VIC5A earth model. The depths computed, as indicated in Tables 2 and 3, seem on average to be a little greater than 10 km. This is a significant change to earlier studies, where the earth model used was WA2 (with higher seismic velocities), and the average focal depth was below 5 km. A focal depth of 10km is the adopted value for GA earthquake locations in most of WA, and this suggests that the WA2 model may not be appropriate for use in this region.

4 Conclusions

Four earthquake cluster groups active in the GSR in 2019 have been identified, assisted by relocations which generally use additional data. Possible source locations for the groups are suggested. The temporal and spatial closeness of the Ongerup and Gnowangerup groups suggests a connection between the groups, but its nature is unknown. The VIC5A earth model produces epicentres with deeper focal depths than the WA2 model, and of the models available at present, may be the best one to use in the region.

5 Acknowledgements

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