THE BURAKIN WA EARTHQUAKE SEQUENCE SEPT 2000 – JUNE 2002

MARK LEONARD
GEOSCIENCE AUSTRALIA

AUTHOR:

Mark Leonard, Ph.D., RSES, Australian National University. B.Sc (Hons), University of Adelaide. Has worked for GA since 1990, in a number of roles including: Nuclear Monitoring, Seismic Network Operations, Software Engineering, Earthquake Monitoring and Neotectonics. In 1987 to 1989 he worked for several land seismic companies in central Australia. His research interests include: Australian seismicity, correlating seismicity to geology, earthquake location, signal processing, onset time pickers, S phase detectors, microseismic noise, neotectonics of the Australian crust and developing a seismicity model of Australia

Introduction

The Burakin earthquake sequence has been the most interesting earthquake sequence in Australia in the last decade. The sequence began in September 2000 with a swarm of 1700 earthquakes, the largest of which had a magnitude of 3.6ML. On 28 September 2001 a magnitude 5 earthquake occurred and has been followed by more than 16,000 recorded "aftershocks". The centre of this activity was between 7 and 14 kilometres west of Burakin. Some of the people who live in the source region have felt several thousands of these earthquakes, while people in the town of Burakin itself have felt up to several hundred events. Many buildings within 25 kilometres of the activity have suffered minor damage, although none has suffered major structural damage. This level of damage is what we would expect from earthquakes which all have a magnitude of 5 or less.

Discussion

Figure 1(a) is a plot of the earthquakes, which have been located, and magnitudes calculated. As yet only a small fraction have been located and only since April 2002 have earthquakes of magnitude less than 2.5 been consistently located. The histogram below (Figure 1(b)) shows the number of earthquakes from the sequence recorded at the nearest permanent station of the national seismograph network station (Ballidu) each day. During this time period, 6 earthquakes of magnitude 4.5 or greater occurred (table 1). The sizes of earthquakes recorded at the nearest station ranges from magnitude 5.2 to 0. Most of the earthquakes in the sequence are aftershocks of the six largest earthquakes. This is typical of earthquake sequences in southwest Western Australia.

This is the highest level of seismic activity experienced in Australia since the 1988 Tennant Creek M6.7 earthquake. The last time south west WA was this seismically active was in February and March 1982 when the town of Manmanning experienced a sequence of earthquakes similar to this sequence. Manmanning is 40 km south of Burakin (Fig 2). That sequence was slightly more active than the current sequence, but the high level of activity lasted only two months. In 1979 a M6.0 earthquake occurred near Cadoux (20km south of Burakin). Both the Burakin and Manmanning sequences are thought to be related to the 1979 Cadoux earthquake.

Date	Time UTC	Latitude	Longitude	Magnitude	Locality
28 Sep 2001	02:45:56.6	-30.49	117.05	5.0	Burakin
28 Dec 2001	16:31:36.5	-30.56	117.05	4.5	Burakin
05 Mar 2002	01:47:39.2	-30.49	117.10	5.1	Burakin
05 Mar 2002	03:29:57.8	-30.50	117.08	4.6	Burakin
23 Mar 2002	13:16:24.1	-30.41	117.44	5.1	Burakin
30 Mar 2002	21:15:48.0	-30.41	117.44	5.2	Burakin

Table 1. Table of origin information of 5 earthquakes of the Burakin series with magnitude 4.5 or greater.

Following the first earthquake in September 2001, Geoscience Australia deployed a number of seismographs in the area. For most of 2002 Geoscience Australia has had 9 seismographs within 100km of Burakin. Data from these instruments will allow us to accurately locate these earthquakes. The 2 ML5+ earthquakes in March are the best

recorded large earthquakes ever recorded in Australia. This data will allow us to better understand earthquakes in Western Australia and the ground motions excited by earthquakes in Australia. This will allow us to significantly improve earthquake hazard maps that are used as input into the Australian Building Code and the assessment of the vulnerability of existing structures to earthquakes.

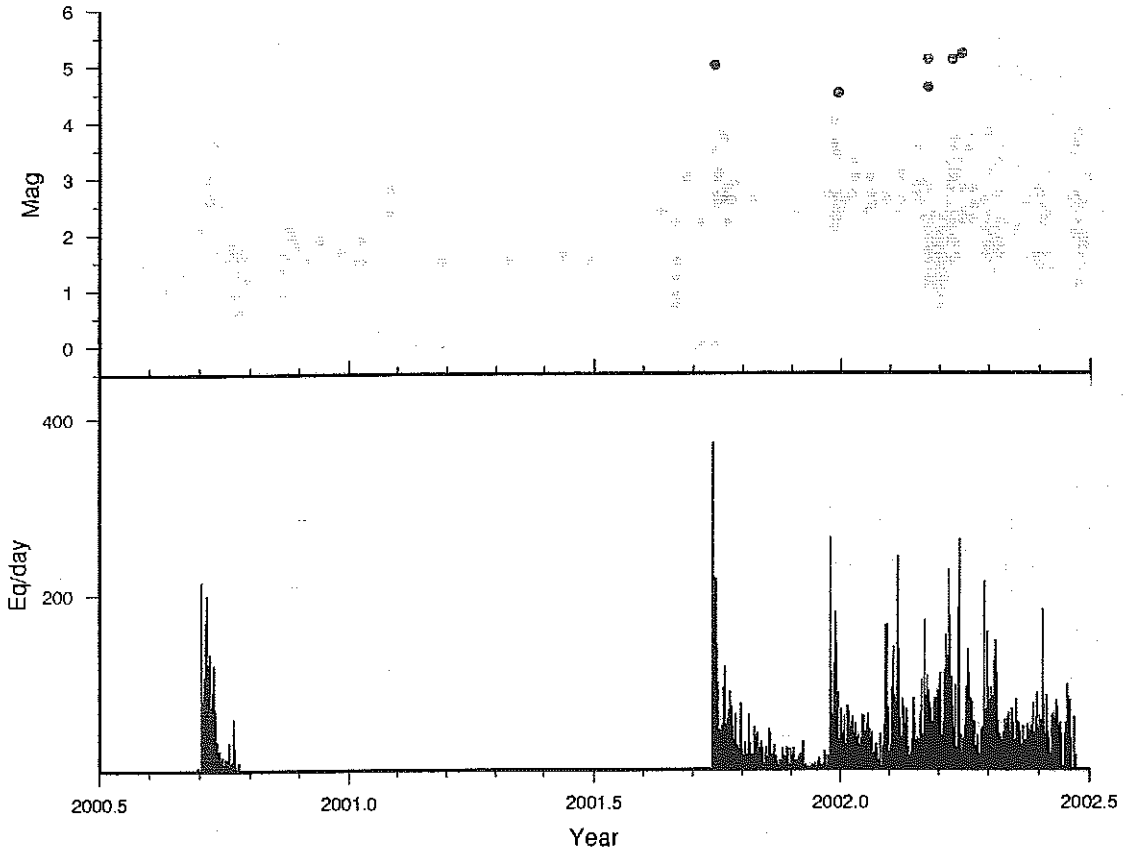

Figure 1. The Burakin earthquake sequence from July 2000 to June 2002. Red dots are the largest six events listed in table 1. The yellow dots represent every earthquake which has been analysed in the sequence. The analysis of earthquakes below Mag 2.5 has been inconsistent during this period. The histogram shows the daily number of earthquakes recorded at the nearest permanent station of the natioual network (BLDU).

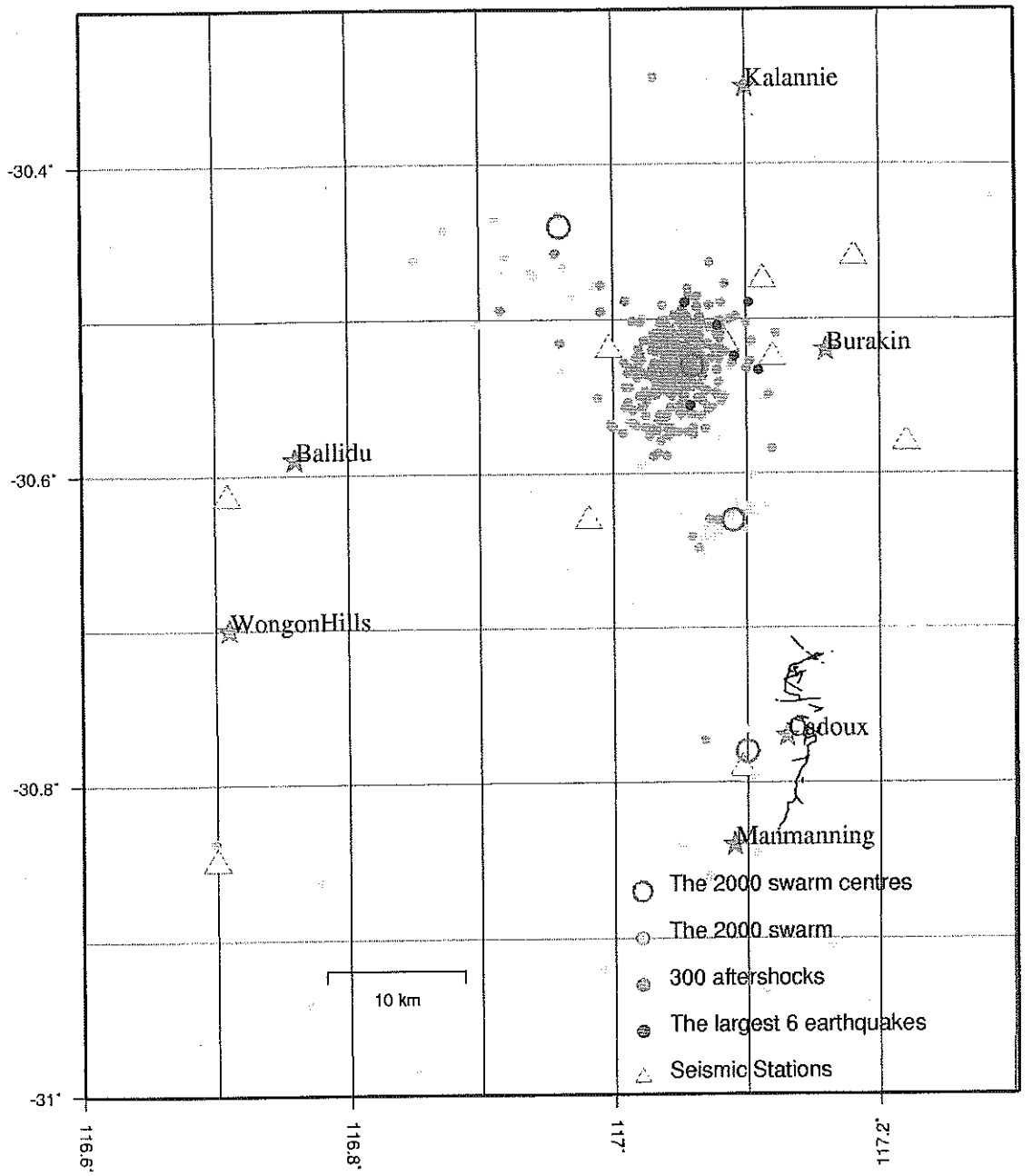

Figure 2 Map of the earthquakes in the Burakin and Cadoux areas since September 2000. The lines near Cadoux are the surface trace of fault scarp formed by the 1979 Cadoux M6.0 earthqnake.

Initial analysis indicates that all the earthquakes are in the top 5 kilometres of the crust. Most well located events locate to the top 10km and many events show an Rg phase. There appears to be 2 or 3 types of events one of which don't produce an Rg phase. Figure 3 has four parts. Figure 3a shows the number of earthquakes per day in the 192 days from September 28th 2001 to June 30th 2002 on a log scale. 3b shows the same things for the period between December 25th 2001 to June 30th 2002. Some of the main features of these plots are:

- We probably underestimated the number of earthquakes in the first day. This is due to the fact that many smaller earthquakes could not be seen in the coda of

other events. Also the nearest station (BLDU) was down for many hours in the first two days so data was used from the next nearest station (KLBR) and extrapolated to be consistant with the BLDU count.

- The first 89 days show a classic aftershock decay sequence with an Omori decay rate of 1. In other words over a period of 100 days, the number of earthquakes per day is reduced by a factor of 100.
- On day 90 (December 28th) there is a marked jump in activity which coincides with the magnitude 4.5 event. Over the next 40 days there is a gradual decline with an Omori decay rate of about 0.15.
- On February 4th there is another marked jump in activity with no clear decay in the activity over the following 150 days.

Omori decay rates of 0.8-1.8 are typical for aftershock sequences of large earthquakes up to magnitude 6, and decay rates of <1.0 are typical for foreshock sequences. Decay rates >1 are expected for aftershock sequences of a single large (mag.>7) earthquake, for example the 1987 Tennant Creek foreshock sequence had an Omori decay rate of 0.25 and the 1988 aftershock sequence had a decay rate of 1.0. This would suggest that the original M5 event in September is a main shock followed by a typical aftershock sequence lasting until December. Whether the activity in 2002, particularly since February 4th, is fundamentally different to the late 2001 activity is not clear. One possibility is we are observing the aftershock sequences of multiple events. With these aftershock series may be combining to give the appearance of relatively constant activity. This would imply that the 6 largest events are on "new" faults and not reactivating the September 26th fault. Another possibility is that the activity is constant and still comprises a foreshock sequence. Whatever the answer their does appear to be, as yet unexplained, three separate phases to the ongoing Burakin sequence.

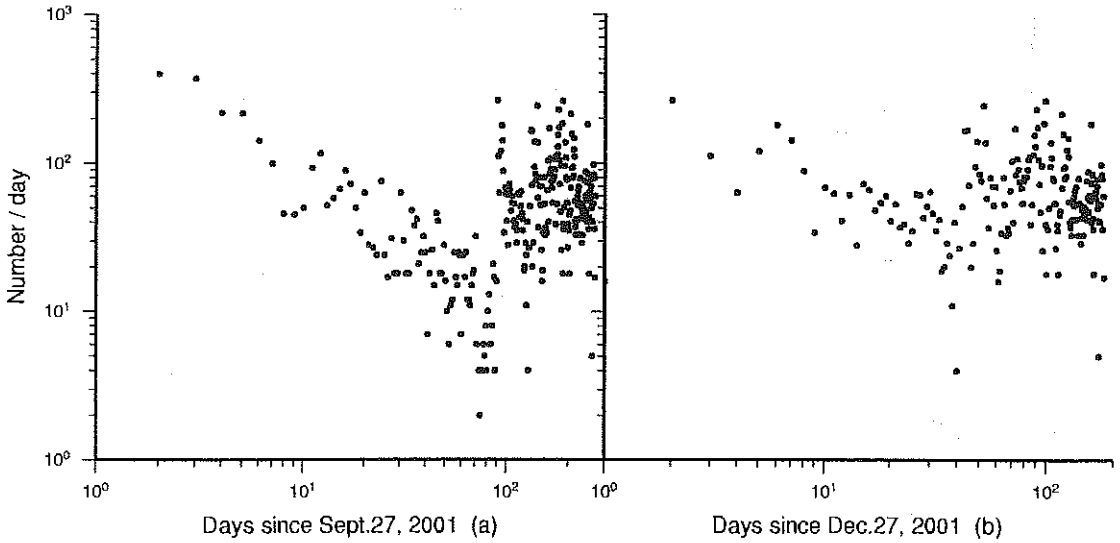

Figure 3 Number of earthquakes observed per day plotted on log-log scales. (a) is for the 300 days since September 27th and (b) is for the 200 days since December 27th.

The b value of the sequence appears to be less than 1. With 8 earthquakes between 4.3 and 5.2 a b value of 1 would predict 500+ earthquakes between 2.3 and 3.2. Even

with the limited data analysed so far, we know this is not the case. What the b value is has not yet been determined, but clearly it is less than 1. As yet none of the six largest events have been located with sufficient accuracy to determine if they are in different areas of the source zone. Nor have all the small events to see if they can be allotted a particular large event. Locations to date suggest that the March 2002 M5 earthquakes are about 5 km west of the September 2001 event, but as very little data from the temporary stations has yet been analysed the location uncertainties are larger than 5km.

Future Research

The data collected from both the temporary and permanent stations around Burakin will allow some significant advances in our understanding of the seismicity of Australia. Areas of research include:

- Relocation using techniques such as JHD and Double Difference
- Identifying the fault plane of the five earthquakes
- Quantifying the rate stress transfer and post seismic deformation
- Calculating fault area, stress drop and moment magnitude
- Strong motion attenuation in SW WA
- Statistical analysis of the swarm and aftershock sequences
- Moment tensor calculation and rupture inversion