AMATEUR SEISMOLOGY IN AUSTRALIA – A REVIEW

Vic Dent

Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

1. THE DEFINITION

While significant financial resources are being invested in new seismic systems, particularly in the post-December 2004 world, little attention has been focussed, in Australia at least, on the possibilities of amateur seismology. For the purposes of this report, amateur seismology refers to seismographs which are not part of, or sponsored by, major governmental or commercial organisations. However, in some (many?) cases they would not be operating except for the often unofficial assistance of these organisations.

The digital revolution has brought costs down, and brought seismology within the reach of amateurs running on low budgets.

Amateur seismic systems can be broadly divided into two main categories.

1) Budget "build-it-yourself systems, based on long-period pendulum devices, oriented towards schools and education.

2) Systems using higher-tech geophones, quality seismic amplifiers, budget Analogue-to-Digital converters, and recording on PC's.

Systems oriented towards schools may be simpler and cheaper, but currently do not deliver quality information. Also, if they are of low sensitivity, they may record few events.

While systems might be relatively easy to set up, it may be difficult to maintain interest if little or nothing is recorded. This factor is more relevant in a country of low seismicity like Australia. However, even just recording passing cars and people, and windy days, can be educationally significant.

2. PRIVATE SEISMIC OPERATORS IN AUSTRALIA

The discussion below describes some of the more significant, or more current activities by amateur seismologists. Stations are listed in Table 1 and plotted on Figure 1, and websites relating to amateur seismology are listed in Appendix 1. There will be some small operators whose activities I am unaware of, or were of such short duration that they do not warrant mentioning here.

New South Wales

There are a number of amateur operations in NSW, the most significant of which may be that run by Dale Hardy at Mark's Point, just south of Newcastle, who built a Gundersen-Shackleford style Long Period seismometer, based on a 1975 article in *The Scientific American* (Strong, 1975). Current seismograms are displayed on his website (Appendix 1). A similar instrument was then built by his friend, Colin Stuart, and is located close by at Swansea. Colin built a third instrument

to the same design, and this is operated by Andre Phillips in Coonabarabran, northern New South Wales. Seismograms from this site are posted on his website (Appendix 1).

Another significant contributor is Dave Dobeson, a high school science teacher at Turramurra (Sydney). Dave received the support of the University of Sydney for a year (2005-06?) to develop a budget seismic system, and to get it into schools. Dave was inspired by a 1979 article in *The Scientific American* (Walker, 1979), describing the "Lehman Seismometer" and how it could be cheaply built. He was awarded the University of Sydney Science Teacher's fellowship in 2005, and devoted that year towards the development of his high-school oriented system. A critical part of this was a data-logger, a variety of which had been provided to all schools in NSW. This was the most expensive part of the system, but the rest of the system could be constructed very cheaply if the enthusiasm was there. However, the quality of timing was poor. The principle behind the seismograph, and how to construct it, was described by Dobeson (2005). It is broadly based around the Lehman seismograph described as above (Strong, 1979), and has been nick-named as the "garden gate" seismometer.

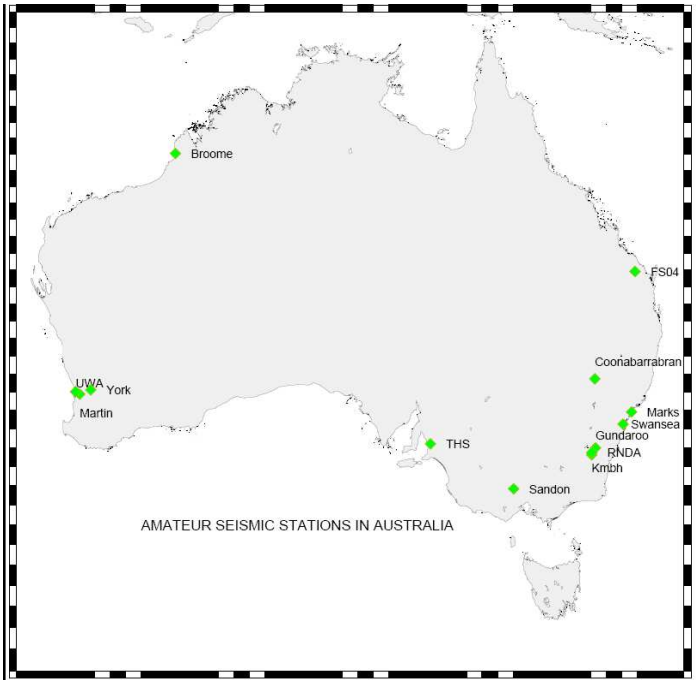

Figure 1 Amateur seismic stations in Australia

This kind of system has the advantage that it demonstrates very clearly to students the physical principles behind the detection of ground vibrations. It also responds well to large destructive events overseas, which capture the media's (and the childrens') attention. It has the disadvantage of not providing any useful data to the seismological community, and therefore gets little support from them. Despite Dave's enthusiasm, the system has been successfully installed in few if any schools, other than Turramurra.

Of course, the most significant contribution by amateurs in NSW could be said to be that of the Society of Jesus (the Jesuits), who established the Riverview Observatory at St. Joseph's College, Sydney in 1909 (Doyle & Underwood, 1965, Udias & Stauder, 2003). This was the first significant continuously recording observatory in Australia, and is still the main source of seismic data in its region. However, even with such a significant facility, the science of seismology has not made much encroachment into the science curriculum for the students at the college

Queensland

The main champions of school seismology in Queensland are Dion Weatherley and Col Lynam of the University of Queensland. The UQ push has been towards getting Kelunji Classic or Echo instruments into schools. This would involve raising about $10,000 per system, and so far the initiative has not been very successful. While the cost might be considered on the high side, it could also be argued that perhaps the system is a bit too technical for the average class-room situation. Also, some processing is required before a visual representation of the events is available for the students. On the other hand, a network of Kelunji instruments could provide very useful information to the seismological community.

Mike Turnbull, of Central Queensland University (Bundaberg campus) operated a small local Kelunji Classic network with up to four stations operating simultaneously in what was known as the North Burnett Seismic Network (NBSN). This network has recorded a number of local events which were undetected elsewhere and not listed in the national database. Unfortunately, due to equipment failures and lack of funding, this network has now been reduced to a single operating station (FS03)

The Australian Capital Territory

Amateur seismology has been well served in the ACT by the efforts of Marion Leiba, operating an MEQ seismograph from her home in Kambah since 1985. This has picked up many small events in the vicinity of the ACT, and assisted in their location.

Kevin McCue has recently set up a Kelunji Echo system at his home in Aranda. It can be anticipated that high-quality data will come from this recorder. However, the cost of the equipment is outside of the affordability range for most amateurs. Data from this station goes “live” to the new network run by the South Australian Government (PIRSA).

A seismograph using a Webtronics (PSN) digitiser and software has been installed recently (June 2007) at Gundaroo Primary School, approx 50 km N of Canberra. This is the same system as described by Dent et al (2006), and continuous binary data is sent in hourly blocks to the website of the Australian Centre for Geomechanics in Perth, where it can be analysed by authorised persons. Virtually no input is required from staff at the school. It is hoped that this will produce useful arrival time data in the event of a local earthquake. It has the disadvantage of relatively high cultural noise levels – during the daytime at least.

Western Australia

Arie Verveer, a technician at the Bickley Astronomical Observatory, operated a high standard seismological system there for many years (1999-2006) which unfortunately is now closed. In its final configuration, it used Webtronics “PSN” software and a number of quality seismometers. The site was seismically very quiet, and picked up most significant WA events very well, as well as many events from the Indonesian region. A very positive feature of Arie’s system was that current seismograms were posted to a web site; and this provided to interstate seismologists a ready appraisal of recent seismicity in Western Australia. The site would have been even more useful had it not been relatively close (approx 20 km) to the observatory at Mundaring, operated by Geoscience Australia.

Another significant operator in Western Australia is Alby Judge. He has also operated his "Martin Observatory" near Perth for many years now. Alby operates several different systems alongside each other, including a Webtronics PSN system. Unfortunately, his system does not deliver current seismograms to a web site. Also, it was quite close to the Bickley site, although that is not an issue now.

Recent additions to the WA "amateur" network include three "PSN" stations. The first of these is a conversion of a long-period helicorder type instrument, which was originally set up by Hugh Doyle at The University of Western Australia in about 1980. The other two are instruments I have installed in schools in Broome (Northwest WA, July 2006) and at York (100 km east of Perth, April 2007). They deliver live seismic data to the (restricted access) ACG web site. Unfortunately at the time of writing only the Broome instrument has GPS timing. As with the Gundaroo (NSW) instrument, school staff is not involved in the day-to-day running of the seismograph, but have been coached on how to do essential maintenance on request. They have used seismograms from their equipment for some basic lesson material, but it has not become an important part of their curriculum.

The UWA Long Period seismograph posts seismograms every 2 hours to the web site http://cyllene.uwa.edu.au/~vdent/SEISMIC. Seismograms from the UQ seismograph at Mt. Nebo and from a site in Canberra run by the author have also recently been added to this site.

Victoria

Following the lead of other seismologists, Gary Gibson intends to operate an amateur seismograph from his home at Sandon in central Victoria for many years. It currently uses Kelunji recorders, similar to those used by the Seismology Research Centre at other regional seismic stations. This station is particularly useful in that it is recording small events generated on the nearby Muckleford Fault. However, the current seismic data are not yet available online.

Table 1 Private Seismic Stations in Australia

STATE	LOCATION	DATE opened	OPERATOR	CODE	SENSOR	Software
ACT	Aranda	1999	Kevin McCue	RNDA	Willmore	Kelunji
	Kambah	Dec 85	Marion Leiba	KMBH	L4C	MEQ
West. Australia	Martin	1989	Alby Judge		Willmore Mk II	PSN
	Nedlands	1972	UWA		Sprengnether LP	PSN
	Broome	July 2006	Broome SHS		Willmore Mk II	PSN
	York	April 2007	York DHS		4.5Hz geophone	PSN
NSW	Mark's Point	Jan 2006	Dale Hardy		Gundersen-S	PSN
	Swansea	Jan 2006	Colin Stuart		Lehmann	PSN
	Coonabarabran	Jan 2006	Andre Philips	CBB	4.5Hz geophone	PSN
	Gundaroo	July 2007	Primary School	GUND	Willmore Mk II	PSN
	Turramurra	2005	Dave Dobeson		Lehmann	
South Australia	Modbury Hts	1988	Modbury SHS	THS		
Victoria	Sandon	Feb 2006	Gary Gibson	S88B	Sprengnether S7000	Kelunji
Queensland	Gin Gin		Mike Turnbull	FS03	Sprengnether S6000	Kelunji

South Australia

With assistance from the SA Dept of Minerals & Energy, a quality seismograph was established in 1989 at Modbury Heights High School (THS), approximately 30 km north of Adelaide. The station is operated by students, or ex-students of the school, and the helicorder charts are posted to the state seismological centre in Adelaide for analysis. It provides important data to assist with monitoring of local seismicity.

Tasmania

While I am not aware of any currently operating independent seismographs, Tasmania (specifically Launceston) was the site of Australia's first (and possibly most significant) private seismoscope to date. It was built and operated by A.B. Biggs, and recorded some of the very significant magnitude 6 plus events in the Bass Straight region of 1884 and 1885 (Doyle & Underwood, 1965).

3. INTERNATIONAL EDUCATIONAL SEISMOLOGY

USA

In the USA, the Loma Prieta earthquake near San Francisco in 1989 inspired many hobbyists towards seismology, including Larry Cochrane who developed the PSN (Public Seismic Network) system. Since then, there has been a significant push to get seismology into the class-rooms although again not all have achieved the success they had initially hoped for. The most significant program is that sponsored by IRIS (Incorporated Research Institutions for Seismology) which uses low-cost AS1 seismometers, (which have short period sensors, specially filtered to make them behave like long-period instruments). John Taber, of New Zealand, was appointed to the position of Education and Outreach Manager (to the detriment of the schools seismology program in New Zealand!).

New Zealand

In New Zealand, the "Quaketrackers" program promoted the introduction of seismographs in Schools in the late 1990's. Approximately a dozen systems were introduced, using Larry Cochrane's PSN equipment. This was supported by government funding for a time, but the systems gradually failed after funding was discontinued, and key personnel were lost. The equipment cost (over $2000) was relatively high at the time – the same equipment today would cost about $500.

An attempt to revive the initiative is currently underway supported by a new funding grant, and it is planned to use the cheaper AS1 seismic system mentioned above. This will align it with the schools seismology program in the USA and will allow them to take advantage of much of the hardware and software development which has taken place.

Norway

A relatively high-tech network of low-cost seismographs was installed in a number of Norwegian schools in the late 1990's. A new sophisticated free-ware seismic processing system, SEISAN, was developed at the same time. The prime researcher/instigator of this initiative was Eystein Husbye of the University of Bergen (Husbye et al., 2003). However, there is not much information on the

current status of the system, and there are some reports that many of the systems are no longer operating, or not operating to original specifications.

The United Kingdom

A new initiative to introduce seismographs into UK schools commenced in 2007, under the *Science Enhancement Program* (SEP). Lehman pattern suspended pendulum horizontal seismometers were made available for purchase by schools. The initiative is too recent to assess how successful it has been.

4. PROS AND CONS OF AMATEUR SEISMOLOGY OPERATIONS

Potential advantages

It has frequently been stated that ideally there should be a seismograph every 100 km across the Australian continent. The consequences of poor station distribution are well shown in Fig 5 of Sagar & Leonard (this vol). South-east Australia has been well covered since the 1980's, with the SRC operating up to 120 stations there. On a continental scale, the first significant "infill" of the Australian continent came with the installation of the "JUMP" network (Joint Urban Monitoring Program) into major Australian urban centres following the 1989 Newcastle earthquake. There are currently 32 sites in operation (Dent & Leonard, in prep). However, this is only a small step towards the "ideal" stated above. However, if even only one in 100 schools could have an operating seismograph, we could be much closer towards the goal of better monitoring the Australian continent.

Amateur seismology could see quality data acquired at low cost. Figure 2 shows two local earthquakes (18 Aug 2007, Ml 2.6 and 3.2) recorded on Black Mountain, ACT, by a temporary PSN system with a 4.5 Hz geophone at an epicentral distance of 140 Km.

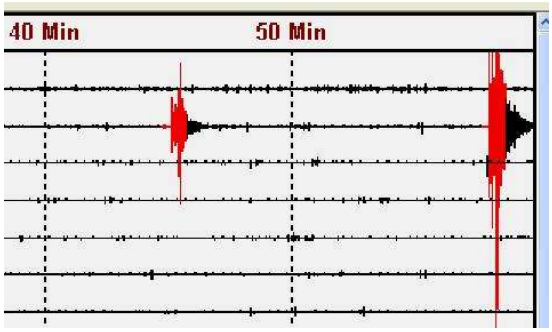

Fig 2 Local earthquakes on a PSN system

Data may arrive from a critical location or from a direction not covered by the regional network. Event locations could be improved, or new events noted that might have otherwise gone un-noticed. More amateur stations would result in a heightened community awareness of seismology, which might ultimately result in a better professional base of seismologists in Australia.

Potential disadvantages

Amateur operators usually cannot site their stations on low–noise sites, and the seismograph will often be sited on a suburban block. Local cultural effects often mean that there are high levels of background noise**.**

While amateur operations may supply useful phase arrival information, they are less likely to provide useful magnitude (ground motion) data. This is because their systems are rarely accurately calibrated and are generally using low-end equipment, particularly the sensors.

There may be significant delays in getting potentially useful data to the agencies that need it, and there is no professional oversight of quality-control procedures at the sites. Often their seismographs may be close to high-quality stations already installed, and hence their data is less useful.

In the current world, waveform data in an acceptable format are desired in addition to the P and S arrival times. However, on the positive side, the current low cost of GPS equipment should ensure that good timing is achievable at all locations.

5. CONDITIONS NEEDED TO PROMOTE THE ESTABLISHMENT OF A HEALTHY AMATEUR/SCHOOLS SEISMOLOGY PROGRAM

1) Guidance and mentoring. To initiate and maintain a viable amateur seismology program, a core body of enthusiastic and experienced seismologists must be prepared to donate their time and knowledge.

2) Financial support. Given the low cost of many essential items, a relatively small amount of money could help achieve significant development.

3) Feedback. Without some acknowledgement and appreciation of the efforts of people giving their time, knowledge or financial support to the project, interest is likely to flag.

6. SUMMARY

There is a significant group of individuals in Australia who deserve recognition and thanks for long-term dedication to collecting seismic data on an unpaid basis.

There are two approaches to an amateur seismology program. One is to use low-tech and cheap equipment, which is good for education but not for collecting useful scientific data. The other is to use higher-tech and somewhat more expensive equipment, with the potential to collect scientifically useful data.

Those using the low-tech approach should be encouraged to upgrade their systems and offered support to do so where needed. This could be a cost-effective method of increasing the amount of useful seismological data currently being collected.

While there are government sponsored schools programs in many other developed nations, this does not yet exist in Australia. A seismic system with good timing can be put into a school for a basic cost of about $500. Systems recently introduced into some Australian schools have demonstrated that useful phase arrival data can be recorded on inexpensive systems.

A body or club of amateur seismologists and those willing to contribute to such a program would be useful. It would provide a venue to educate, coordinate and encourage the participants in such a program.

7. ACKNOWLEDGEMENTS

I would like to thank David Love, Clive Collins and Mike Turnbull for their reviews and comments on the manuscript, and Col Lynam for his enthusiasm for educational seismology.

8. REFERENCES

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APPENDIX 1 -- Web Sites relating to amateur seismology

WEB SITE	COMMENTS
http://www.quaketrackers.org.nz/seismograph.html	not recently updated
http://www.amateurseismologist.com/	- IRIS buys the AS1 from here
http://www.turramurra-h.schools.nsw.edu.au/library/asp/quake/quake.asp	- live feed from Turramurra
http://www.iris.washington.edu/edu/AS1.htm	Description of AS1
http://psn.quake.net/lehmntxt.html	- reproduction of 1979 Scientific American Article – Lehmann
http://science.uniserve.edu.au/school/Seismograph/menu.html	Dave Dobeson's site
http://cyllene.uwa.edu.au/~vdent/SEISMIC	"live" UWA and UQ seismograms
http://www.bgs.ac.uk/education/schoolseismology/seismometer.html	UK School seismology program
http://www2.ifjf.uib.no/SEIS-SCHOOL/	Norwegian site (inactive?)
http://www.mgm.monschau.de/seismic/	German schools site
http://www.map.id.au/seismic/	Coonabarabran Seismic Station

http://www.daleh.id.au/index.html	Dale Hardy, Mark's Pt., NSW
http://seismo.cqu.edu.au/	Mike Turnbull, Queensland