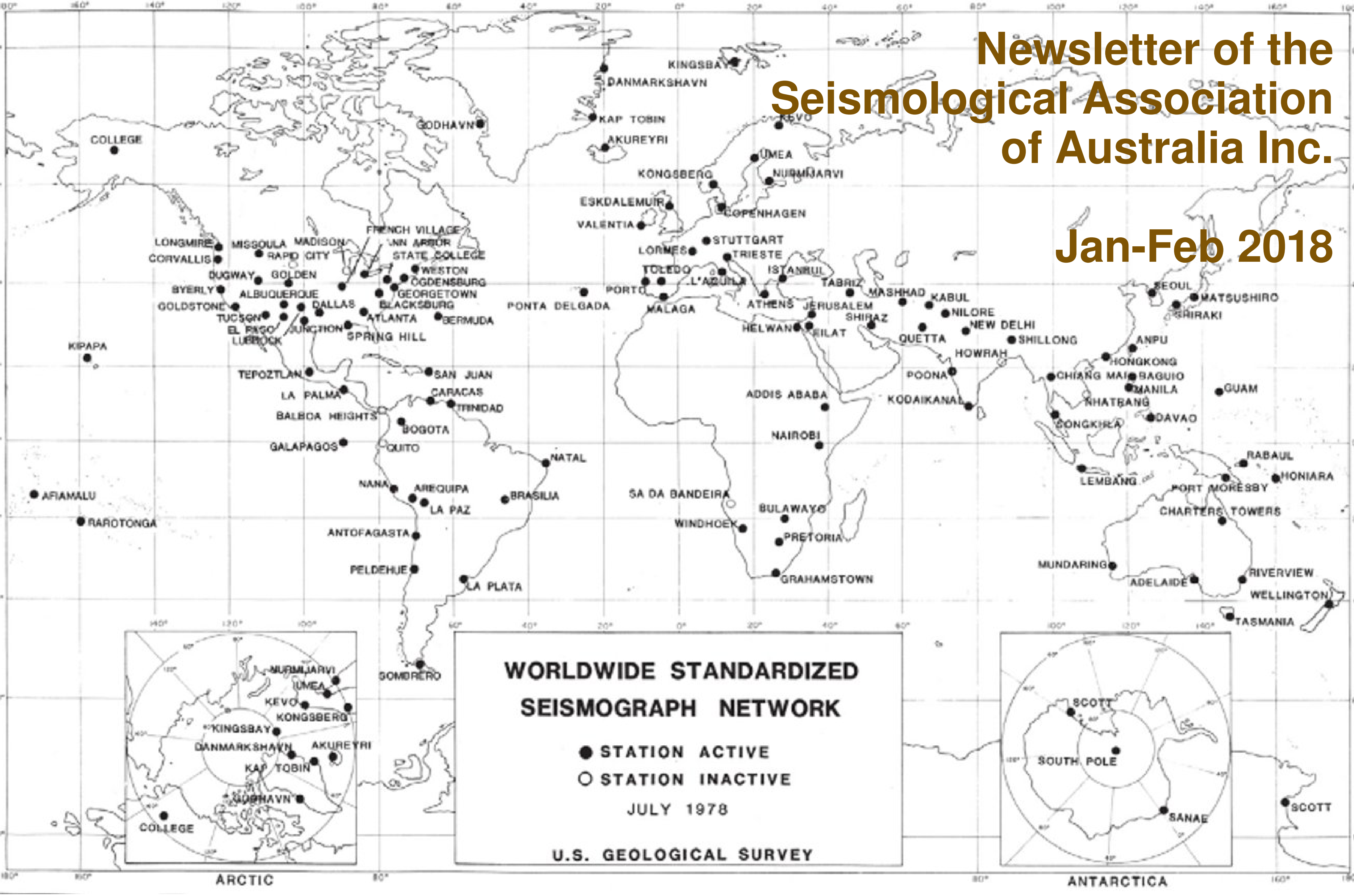
Newsletter of the Seismological Association of Australia Inc.

Jan-Feb 2018



Seismological Association of Australia Inc.

Newsletter of the
Seismological Association of Australia Inc.
PO Box 682, Mylor SA 5153

Your Committee

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The SAA can be contacted by post to the address above, or by email to any member of Committee, as listed above

Membership of the SAA is open to all, with the only prerequisite being an interest in seismology. Membership applies for the calendar year (January through to December)

Membership fees are:
Full member $50

A Membership application form can be obtained from the Treasurer.

Member Submissions
Submissions for inclusion in the Newsletter are welcome from all members; please note that submissions may be held over for later editions. Wherever possible, text submissions should be sent via email in almost any word processing format. Your name may be withheld only if requested at the time of submitting. Images should be high resolution and uncompressed, although high resolution JPEGs are acceptable.

All enquiries and submissions should be addressed to the Editor and preferably sent by email to weaksignals@iinet.net.au

A word from the Chairperson

Welcome to our first newsletter for 2018.

What will 2018 bring us? January is over and so far a couple of volcanoes erupting in the Philippines and Japan, triggering avalanches and mud slides and some earthquakes of interest

The M7.9 near Alaska only generated a small tsunami (<12” high) however, the endangered Desert Pupfish in Nevada were shaken and had a mating frenzy!

https://www.smithsonianmag.com/smart-news/endangered-desert-pupfish-spawn-wake-alaskan-earthquake-180967961/

An M7 near Peru, the usual smattering of events around PNG and Indonesia, a M6.5 of the coast of California and a swarm of little events near Nambucca Heads on the eastern seaboard of Australia.

Again, the lack of resources to monitor events

continued next page

A word from the Chairperson
continued

such as these in populated areas in Australia is evident. The nearest permanent instrument is in Armidale, some 50km to the west.

We need more permanently installed instruments and a bunch of easy to deploy instrumentation for strong motion events along with funds for people to carry out deployments and analyse data.

Perhaps crowd sourcing or citizen scientists are going to be the ONLY way to get better coverage throughout regional Australia.

Are Australians more interested and prepared to spend taxpayers monies on things like plebiscites than science?

I do hope the answer is no.

Blair Lade
Chairman SAA

"Post Script to The state of Seismic monitoring in Queensland (see Page 5)

By Mike Turnbull

Since penning the original article two significant pieces of information have come to hand.

Adrienne Moseley, Leader of the Earthquake Alerts & Tsunami Warnings centre at Geoscience Australia has provided a detailed clarification of the methodology used at GA to guide their processes of detection, location, and cataloguing of Australian earthquakes, and the archiving of seismogram data. This clarification confirms the standing practice of issuing alerts for all M3.5 and greater, but details the additional non-alert processing that occurs for sub-M3.5 events. It also outlines the process of archiving of High Sample-rate Data (HSD) at GA; data that, although not made publically available online, is available on request.

This author has been informed that GA and SEQWater have opened informal discussions that may result in GA being able to access the live SEQWater seismic data and make it publically available in that same manner that it does with its other data. If that prospect eventuates it is a win-win situation; SEQWater makes the data publically available via the IRIS web service, and GA can use the data to achieve better surveillance of earthquakes in Queensland.

I will be meeting with the SEQWater Manager of Water Source Services (Rob Drury) before this article is published to discuss the ongoing need to ensure that Queensland's seismic monitoring network is properly maintained and serviced. Hopefully, in future newsletters, I will be able to confirm that the state of seismic monitoring in Queensland is on the mend."

SAA News & rumblings

SAA Newsletter on Dropbox
This edition of the SAA Newsletter was probably downloaded by you from Dropbox. Dropbox is a cloud based file storage facility that allows me (Editor) to save this (and other documents) and enable you to access these files in a couple of ways. You do not need to have a Dropbox account to access the file, I will send you a link to the SAA Newsletter file via email and you will be able to download that file from Dropbox.

If you are willing to allow me to add your email address to my Dropbox account, I can give you access to all the SAA Newsletters. You will need to ask me to do so because I will not do this without your specific consent. If you have your own Dropbox account, I can link you to the files directly and you can download whatever you want, whenever you want.

In anycase, you will receive an email when each SAA Newsletter is available for you to download.

SAA at 2018 Science Alive
The SAA has registered interest in participating at this year's Science Alive, held at the Wayville Showgrounds in August. The SAA Committee will be looking for ideas, suggestions and volunteers to participate at this event. Should you be able to assist in whatever way, please contact the SAA Treasurer, Joe Grida at your earliest convenience

SAA takes legal possession of GSSA assets
The SAA Committee recently receive formal confirmation from the SA Dept. of Premier and Cabinet by way of a "Declaration of Surplus Seismological Equipment Transfer", Ref 2017D026646 and dated 7th November 2017. The declaration states that the excess equipment from the closure of the Geological Survey South Australia (GSSA) had been formally transferred to the SAA. You may find and read some snippets of further information relating to this "equipment transfer" on other pages of this Newsletter. Call it gloating if you will, but it is now finally legal.

Bunnings BBQ Fundraiser
Further to the SAA Newsletter #3 announcement of our intention to participate in a Bunnings BBQ Fundraiser. At the date of publication, I have not received any advice from Mt Barker Bunnings regarding a scheduled date. Considering the weather in SA lately, I'm quite relieved that they haven't and a date later in the year, rather than sooner, suits me just fine. For the moment I'm happy to wait for them to call us, rather than chase after a booking 'as soon as possible'. We are on the list and our opportunity will come soon enough, hopefully it's going to be in Autumn rather than the middle of this hot, dry Summer.

New Zealand geology: an illustrated guide by Peter Ballance (former Associate Professor, Geology Department, Auckland University).
Michael Andre Phillips of Coonabarabran, NSW has sent us a link to a free downloadable eBook on New Zealand geology. Thanks Michael, we all need some light reading before bedtime.

http://www.gsnz.org.nz/zealand-geology-p-632.html

Can the SAA become a political activist?
On the final page of Mike Turnbull's excellent article "The state of Seismic monitoring in Queensland" is a statement, possibly a plea, to SAA Members

"I encourage members of the Seismological Society of Australia to agitate within their States and federally to ensure that scientific monitoring of earthquake activity within Australia is iteratively evolved, not devolved."

One might easily conclude that the state of the other states are no better. If it is the intent of the majority of SAA members to take up this challenge and rattle a few chains within the various levels of the bureacracy, so be it.

Do you have some interesting news that you would like to share with other members or something seismic you want to sell ? If so, please submit it to weaksignals@iinet.net.au for inclusion in the next edition.

The state of Seismic monitoring in Queensland

The aftershock sequence of the Bowen Aug 2016 M5.8 is still ongoing. We are currently at day 508. In the attached graph the absence of events prior to the main event is not an artefact, it is real. The main M5.8 event initiated a sequence of earthquake events in the 1 degree geo-grid centred on the main event for which there was very little precedence in Australian catalogues. There are only seven earthquakes listed in the GA database in that area from 1982 to 2015; and, apart from a couple of M2.3s, these have been M3.0 or greater – which is pretty much in keeping with GA's remit.

Because of the lack of historical data it is difficult to say for certain whether the current seismicity is normal for this area or not. The hiatus immediately prior to the onset in August 2016 strongly suggests that the current seismicity is primarily caused by reactivation of the area by the M5.8. This is in keeping with observations made by others that many Australian sequences are so long lived that they should be regarded as long term reactivations of areas rather than as true aftershock sequences (as regarded in the classical sense).

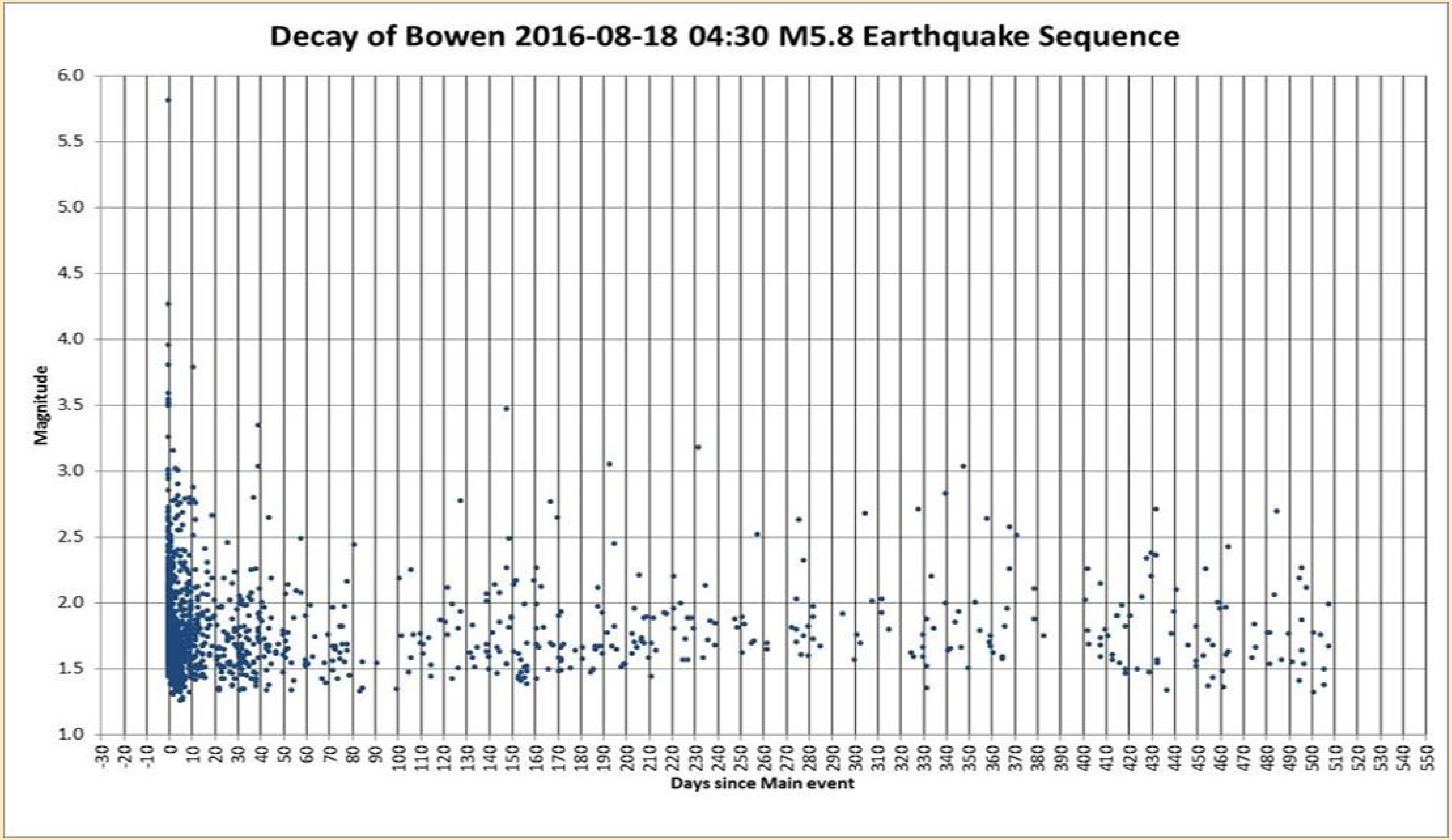
With the Mt Perry area (M5.0 Feb 2015), I am observing a heightened level of seismicity three years after the main event. The Bowen area is following suit it seems. One would imagine that the Rainbow Beach area (Jul/Aug 2015 3xM5.0+) is doing the same thing but they are not being detected due to absence of sufficient monitoring instrumentation.

Although the Bowen decay graph is indicating a very slow reduction in peak magnitudes over the past 508 days, the average magnitude is sitting fairly constant at M1.8, and is not abating. Earthquakes in this sequence are being located from Whitsunday Passage, down through Airley Beach and further south to within a couple of kilometres east of Proserpine.

What this exercise is showing is that, if our (the Australian Seismological community) aim is to provide an indication of where future large events are more likely to occur, there is a need to monitor throughout Australia for seismic activity of M2.0 and greater; not M3.5 or greater. The cost of achieving that goal would be of an order that no individual State Government could afford on its own, and the Federal Government would need to work with the State Governments to achieve it. However, that goal is very achievable, and nationally very affordable. It isn't funding that is lacking but lobbying by the Australian Seismological community. Instead of overseeing evolutionary growth of the Australian seismic monitoring networks as is typical of other Nations (even third world Nations) we are sitting on our hands and witnessing a determined and deliberate decay of the past glory of the post-Newcastle JUMP network and devolution of network operational responsibility by State and Statutory Authorities to GA (in the best cases) and nobody (in the worst cases).

In Queensland a network of 167 state-of-the-art monitoring stations, installed only about four years ago and operated by the South East Queensland Water Company (SEQWater) and the Queensland State water authority (SunWater), is now operating in self-preservation mode. Following installation and commissioning, field maintenance of this facility was carried out by Queensland Main Roads Department (Roadtech) under contract to SEQWater. At that time SEQWater employed a dedicated seismologist to analyse the collected data. That same data was made available to other agencies via a password protected online server (EqServer). The State seismologist was released in late 2015 and not replaced. Roadtech currently has no contract to maintain the field equipment (apparently).

The state of Seismic monitoring in Queensland



The state of Seismic monitoring in Queensland

The SEQWater EqServer went offline in November 2017, and there seems to be no staff at SEQWater who knows how to fix it. A recent email received from the Director, Major Projects and Property, Queensland Department of State Development, confirms that The State Government regards SEQWater and SunWater as the State network operator. Communications sent by this author over the past two months to senior management at SEQWater requesting attention to this matter have, until this very week, gone unanswered. A very brief and not very informative, but encouraging, reply received on Monday 8 January this week provides some hope that action may be taken to redress the situation.

Also in Queensland, the 13 Joint Urban Monitoring Program (JUMP) stations, originally installed in the early 1990s and upgraded to state-of-the-art equipment at the same time as the SEQWater/SunWater networks four years ago, and operated by SEQWater/SunWater on behalf of the then Queensland Department of State Development and Infrastructure (DSDI) and currently named Department of State Development (DSD), were handed back to GA in February 2016. GA refers to those stations as the Urban Monitoring (UM) stations.

Decimated low quality data at 20 sps derived from those stations are publically available via the IRIS DMC Web Services, as are the data derived from the seven Queensland stations of the Australian National Seismograph Network (ANSN).

Geoscience Australia actively monitors for and reports on any M3.5 or greater that it detects within Queensland (and throughout Australia). GA may also follow-up on any sub-3.5 events that are reported as being felt by the public.

This author, as Lead Seismologist of the Central Queensland Seismology Research Group (CQSRG), monitors for low magnitude earthquakes within Eastern Central Queensland; in the region bounded (approximately) north to Mackay, South to the Sunshine Coast, west to Roma, and out to sea some hundreds of kilometres. CQSRG maintains an online catalogue of earthquakes it detects and locates at http://www.cqsrg.org/. This catalogue contains 655 earthquake events entered since 2004, ranging in magnitude from as low as M-0.2 to M6.1 (an earthquake in the Northern Territory). In excess of 75% of the earthquake events listed in the CQSRG earthquake catalogue do not appear in the GA database.

As well as this author, one other Queensland seismologist maintains a Queensland catalogue of currently occurring earthquakes. Russell Cuthbertson, in collaboration with Gary Gibson, has access to much the same data as does this author – with the addition of data from three stations operated by the Seismology Research Centre (SRC) on behalf of the Gladstone Area Water Board. That data is not publically available. Dr Dion Weatherley and Col Lynam, staff at the University of Queensland (UQ), also operate monitoring stations at Brisbane (BRSA), and Monto (MNT), and make data from those stations available publically. The UQ is also the custodian of the J.M. Rynn Earthquake Catalogue (1866-2009) which Dion and Col plan to release for public use later this year.

The absence of data from the SEQWater/ SunWater monitoring stations places severe restrictions on the ability of all agencies, CQSRG, Russell Cuthbertson, and GA, to detect and locate earthquakes that occur in Queensland. This is particularly true of earthquakes of magnitudes below M3.5. However, even when the SEQWater/ SunWater is available, the detection of low magnitude events in Queensland is hit-and-miss. Monitoring capacity is mostly concentrated along

The state of Seismic monitoring in Queensland

the Eastern Coastal Strip, with the exceptions being the ANSN stations at Roma, Quilpie, and Mt Isa a – and there are long gaps in the location of coastal stations all the way up the coast (particularly from Brisbane to Gladstone). All natural seismic activity west of the Great Dividing Range is pretty much ignored by governmental authorities.

The UM stations are not principally designed to facilitate low magnitude earthquake detection and location. Their primary function is to obtain acceleration data during strong earthquake occurrence for engineering purposes. Their sensitivity to low magnitude events is severely compromised; and they are, by necessity, located in noisy urban sites.

In summary, the state of earthquake monitoring for low magnitude events in Queensland is in decline, and the Queensland State Government and its statutory authorities seem to be actively ignoring the situation. Unless something is done to rejuvenate the SEQWater/SunWater networks, the infrastructure cost of several million dollars will be lost and wasted. Even if the SEQWater/SunWater network is brought back on line Queensland will still only have a token-effort monitoring capacity that is totally inadequate for most scientific purposes. At present that network is arguably not in compliance with ANCOLD/ICOLD guidelines. There is little sense in providing a multi-million dollar monitoring network if none of the data that it supplies is actively scrutinised and analysed. The Queensland Government currently does not employ a qualified State seismologist, nor does it sub-contract to any qualified organisation to scrutinise and analyse seismic data that it collects.

I encourage members of the Seismological Society of Australia to agitate within their States and federally to ensure that scientific monitoring of earthquake activity within Australia is iteratively evolved, not devolved.

"The state of Seismic monitoring in Queensland" article was submitted by Michael Lloyd Turnbull BAppSc(Distinction) QUT, MAppSc CQU, C.Dec Lead Seismologist, Central Queensland Seismology Research Group (CQSRG). Adjunct Research Fellow, CQUniversity Australia (CQU).

Horse Camp, Qld. 4671

http://www.cqsrg.org/

A letter from the Editor

Well, seeing that no one has written to me in the last two months... so here I go!

First and foremost, my thanks to the contributors of articles for this issue of the SAA Newsletter. In my opinion, your input has elevated this humble publication to a new level. There are several issues included here that are causing some concern for our members. We have a couple of educational articles relating to current seismic technologies, submitted to help disseminate information to members. Nearly half of the Newsletter relates to our connection with seismic technologies of the past and how we might adapt these for future use.

I am really excited about the next issue, with two follow-up articles being prepared for submission. It's a good start, but... more is needed.

In the last issue, I made a point of the idea that this is ***your Newsletter*** and you can make contributions to it. Sorry, but I was wrong about that. ***It is your Newsletter and you should make contributions to it.*** I hope that this issue has shown that we can (and should) be willing to raise and consider issues we care about, stir the pot and perhaps, make a difference.

I recently purchased a book titled "Eyewitness Volcano & Earthquake" from Aldi, please don't make me use it as a filler. Peter Gray - Editor

A response from Geoscience Australia

Prior to publication of this edition of the SAA Newsletter, we received a response to some of the comments made in the "The state of Seimic Monitoring in Queensland" article on the preceeding pages.

The response was made by Adrienne Moseley, Leader - Earthquake Alerts & Tsunami Warnings | Geodesy & Seismic Monitoring Branch | Community Safety & Earth Monitoring Division and forwarded to us via Hugh Glanville.

The response from GA is reproduced here in full, as follows:

CQSRG's article: "Decimated low quality data at 20 sps derived from those stations are publically available via the IRIS DMC Web Services, as are the data derived from the seven Queensland stations of the Australian National Seismograph Network (ANSN)."

Comment: GN has commenced transitioning the UM sites from telemetering data from the 3-C short-period seismographs and Z of accelerometers from 20sps at 40sps*. The changes for each site require (a) sufficient bandwidth/bit-rates for transmission; and (b) reconfiguration and testing for operational impacts (Antelope & SeisComP3). *this is for telemetered data. In relation to acquired & archived data, following an earthquake M≥3.0, or by special request, GA downloads and archives high-sample rate data (HSD) at 200sps, from the seismographs and accelerometers of its telemetered networks (UM and ANSN). The data are archived on the Continuous Waveform Buffer (CWB) and are presently available in CSS3.0 format. GA is investigating transferring all data to SEED format and archiving to a more easily accessible platform than CWB.

GA download and archive high sample-rate data (HSD, 200sps) as follows:

1. (Routinely): in the event of an Earthquake within Australia and its Territories, according to the magnitude and epicentral distance (source-station) criteria tabulated below; and/or

2. (ad-hoc): as requested by a GA seismologist.

Below are the criteria used to identify data to be archived at 200sps.

Magnitude	Target stations:	Duration
$3.0 \le M < 3.5$	If 1 or more UM or ANSN station is within 100km, then: Download HSD from all UM & ANSN stations, $\Delta \le 300$km	In all cases, From 30s before P [Pn, Pg] arrival, To 20min after P [Pn, Pg] arrival.
$3.5 \le M < 4.0$	Download HSD from all UM & ANSN stations, $\Delta \le 500$ km	
$4.0 \le M < 4.5$	Download HSD from all UM & ANSN stations, $\Delta \le 1{,}500$ km	
$M \ge 4.5$	Download HSD from all UM & ANSN stations, $\Delta \le 2{,}000$ km	

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The response from GA is reproduced here in full, as follows:

CQSRG's article: "Geoscience Australia actively monitors for and reports on any M3.5 or greater that it detects within Queensland (and throughout Australia). GA may also follow-up on any sub-3.5 events that are reported as being felt by the public."

Comment: This statement is in reference to our near-realtime (24x7) alerting function, only – not the gamut of our monitoring activities. The suggestion seems to be that we only look at sub M3.5 events if they're reported as felt. In fact, we review all waveforms in post-event analysis to

(a) improve characterisation of events reviewed in near-realtime and alerted by the Duty Seismologist;

(b) review and characterise earthquakes formed by the automatic associator (that did not meet the criteria for near-realtime alerting);

(c) identify and remove false events formed by the automatic associator;

(d) identify and characterise earthquakes not formed by the automatic associator.

Below are the criteria that we use for cataloguing and publishing Australian earthquakes.

Criteria	Notes	Catalogue	Web
Any EATWS-located Australian earthquake, with M≥2.5		Yes	Yes
Any EATWS-located Australian earthquake, M<2.5, and having at least **5 defining phases**		Yes	Yes
Any EATWS-located Australian earthquake, M<2.5 and having fewer than 5 defining phases		Yes	**No**
Where an earthquake is reported to GA as having been **felt in Australia or its Territories, and** is manually located by EATWS in response to that felt report. i.e., the event was not automatically alerted by Antelope, but has been manually located in response to receipt of a felt report.	Event may be located outside Australia (e.g. Banda Sea events felt in Darwin) Applies to events of **any magnitude** (typically, these will be small and/or in an area with very low network coverage). Append description with "(felt report)" e.g., *Mundaring, WA (felt report)*	Yes	Yes
Any EATWS-located earthquake that has been located using **only** GA aftershock deployment data	Append description with "(aftershock deployment)" e.g., *Near Eidsvold, QLD (aftershock deployment)*	Yes	Yes
Any EATWS-located Australian blast for which we have ground truth information (e.g. confirmation of blasting from the mine)	Flag event as a mining explosion (ME). If we have already catalogued 20 blasts from a single source (mine or quarry), discontinue locating blasts from this source **UNLESS they are M≥2.5.** Continue to locate all blasts M≥2.5	Yes	**No**
Any EATWS-located Australian blast for which we have no ground truth, must have at least **5 defining phases.**	Flag event as a mining explosion (ME). If we have catalogued 20 blasts from a single source (mine), discontinue locating blasts from this source **UNLESS they are M≥2.5.** Continue to locate all blasts M≥2.5	Yes	**No**
Note: "EATWS-located" means the earthquake/blast has been located and/or reviewed by the EATWS seismic analysts or a GA seismologist, using the seismic data available to the EATWS. This may not include, for example, small Australian earthquakes located by third parties using privately- or state-operated networks.			

Events from the past

MT. BONYTHON - End of an Era

From it's early days as one of the Australian sites (ADE) for the World Wide Standardised Seismic Network (WWSSN) to early 2017, the vault and equipment installed close to the summit of Mt Bonython had served the Geological Survey of South Australia (GSSA) well.

The photographic recorder room

A Benioff Horizontal on the move

Just a mere 11km from the Adelaide GPO (as an Adelaide crow flies), the facility needed to be cleared out prior to the return of the vault area to Telstra, the leasholder of the property.

One Saturday morning in April 2017, the interim members of the yet to be incorporated SAA made their way up the hill, trailer in tow, to secure and remove the WWSSN historical items for posterity.

After some preliminary work carried out earlier, the Sprengnether 201 Vertical and two Sprengnether Horizontal Long Period (Press-Ewing) Seismometers were carefully dismantled for removal and transportation to their new home at The Peters Seismic Observatory.

The GeoTech 1051 Vertical and three GeoTech 1101 Horizontal Short Period, Variable Reluctance (Benioff) Seismometers, all weighing

The Benioff Vertical heading out the door

Events from the past

in excess of 200kg each, were carefully packed for removal and storage. In addition to these, there were three United ElectroDynamics DR274 and two DR273 Photographic Drum Recorders for the long period seismometers and five GeoTech AR311 Galvanometer Drive Amplifiers for the short period seismometers.

Established in the early 1960s, the WWSSN was one outcome of Project VELA and the key implemetation of VELA Uniform - a Cold War project that was designed to detect the differences between underground or underwater nuclear tests and natural seismic activity. These projects were primarily funded by the US Department of Defence.

Over time, the WWSSN sites proved invaluable in generating information about the earth's interior and its dynamic processes. Data produced by the WWSSN was fundamental to the acceptance of the continental drift/plate tectonics theory, as a result of sea-floor spreading.

While not it's primary purpose, the WWSSN would have been used by the USA to monitor Soviet and Chinese underground nuclear weapons tests, tests allowed under the 1963 Partial Nuclear Test Ban Treaty. In 1967, funding by the US Department of Defence dried up and the WWSSN began to slide into decline.

Left to Right : Jim Deer, John Duffield, David Love, Blair Lade, Paul Hutchinson & David Miller

In 1996 the US Geological Survey terminated the network after a limited number of sites had been upgraded to Global Digital Seismic Network sites. Unfortunately, the ADE site at Mt. Bonython was not included in this program. Since then, the site has been equiped and managed by the GSSA, most recently with a Kelunji EchoPro and a Guralp CMG-6T providing six channels of data to the seismic record. Until its ultimate demise in 2017, the Mt. Bonython seismic vault site served us well.

Have you seen an interesting article that you would like to share with other members? If so and you are able to provide some details of it's source (for copyright reasons), please submit it to weaksignals@iinet.net.au for inclusion in a future edition.

Understanding Earthquake Magnitude - Part 1

ML - Local Magnitude

In 1935, Charles Richter introduced the local magnitude (ML) scale (later referred to as the Richter scale) to quantify medium-sized earthquakes (between magnitude 3.0 and 6.5). This scale was based on the ground motion amplitude measured by an unusual, horizontal torsion seismometer (Wood-Anderson, normalised at a distance of 100 kilometres from the earthquake epicenter) in Southern California. The scale had an upper limit there, the highest measurable magnitude around 7. Magnitude is not defined beyond 600 kilometres though Eiby and others extrapolated the scale to greater distances.

The scale is completely arbitrary and had no physical significance. Most importantly it was limited to distances less than 600 kilometers, by the type of seismograph and to crusts with the same Q (attenuation per cycle) as California.

mb - Body Wave Magnitude &
Ms - Surface Wave Magnitude

Beno Gutenberg expanded Richter's work to consider earthquakes detected beyond 600 kilometers. The ground motion on your long period seismograph from a large distant shallow earthquake is dominated by surface waves (Rayleigh and Love) with a period of about 20 seconds (a wavelength of about 60 kilometers) to which he assigned a surface wave magnitude (Ms). He also used the P-wave ("body waves") amplitude in the first 5 seconds of the seismogram of distant earthquakes to create a body-wave magnitude scale (mb) for periods between 1 second and 10 seconds. Both of these scales were meant to be equivalent to ML.

Learning:

The three magnitude scales were meant to be equivalent measures of the size of an earthquake, they just measured different parts of the frequency spectrum or distance range and on different seismographs. In theory a magnitude frequency distribution normalised for area should be a continuum no matter which of the three scales were used.

Deficiencies in the Ms scale soon became obvious. It was unable to characterize "great" shallow earthquakes accurately (Ms >8) because great earthquakes produce very long period waves (more than 200 seconds) which carry large amounts of energy. And at the other end of the scale it was useless for small, shallow earthquakes as they do not generate 20 second period seismic waves.

Likewise mb was useful for measuring distant deep earthquakes which don't generate surface waves, but only over a narrow magnitude range of 5 to 6.5.

The concept of seismic moment was introduced in 1966 by Keiiti Aki, a professor of geophysics at the Massachusetts Institute of Technology. He used elastic dislocation theory to propose that, during great earthquakes, the peak ground motion amplitude from long-period seismographs is proportional to the product of the fault area that slips, times the average distance that the fault is displaced, times the rigidity of the material adjacent to the fault.

(part 2 next newsletter)

"Understanding Earthquake Magnitude part 1" article was submitted by Kevin McCue.

Kevin has also included this link to a recent article published in the USA, following a recent quake. It might be useful for members to contemplate the engineering aspects.

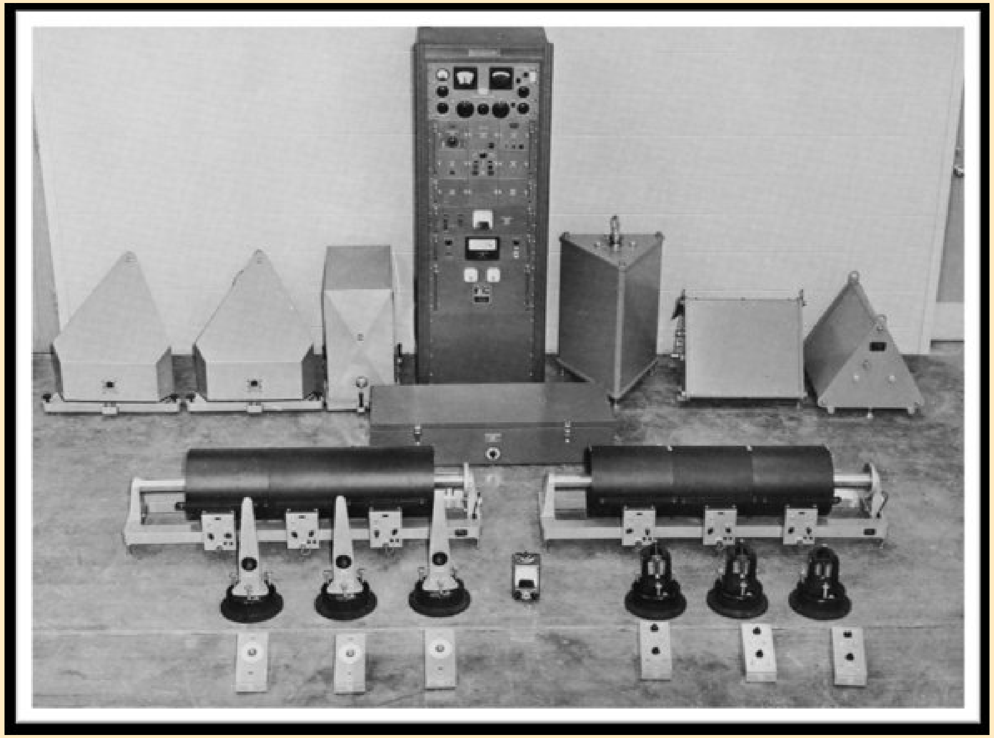
https://www.dailybreeze.com/2018/01/26/is-your-house-prepared-for-an-earthquake-here-are-some-things-to-do/

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

How SAA came to acquire these historic seismographs.
History.
Seismologists in the 1950's recognized the need for a global network of accurately calibrated and accurately timed seismographs. The opportunity to fill that need came as a result of nuclear test ban discussions held in 1958. A panel on seismic improvement, chaired by Dr. Lloyd Berkner, was formed in the United States to consider research needs for improving the national capability in the detection and discrimination of underground nuclear explosions.[1] The panel's report formed the basis of Project Vela Uniform, a program of fundamental and applied research managed by the Defence Advanced Research Projects Agency (DARPA). The new network was not intended for the surveillance of nuclear tests; its role was to produce the data needed for fundamental research in seismology. The recommendation of the project was adopted and implemented as the World-Wide Standardized Seismograph Network (WWSSN).

The task of deploying and operating the WWSSN was assigned by DARPA to the U.S. Coast and Geodetic Survey (C&GS), the principal federal agency engaged in seismological operations at that time. In October 1961, C&GS began installing WWSSN stations at 121 sites around the globe.[2]

All WWSSN stations were installed with an identical equipment set, including three Benioff short period and three Sprengnether long period seismometers. These 121 WWSSN stations for the first time, produced standardised, accurately timed, and accurately calibrated global seismic data, giving seismologists their first opportunity to understand various mechanisms of plate tectonics, as well as coincidently being used to monitor nuclear tests. It was the first-time seismic data was routinely shared across international borders. Over a quarter of a million photographic papers a year were produced by the WWSSN stations around the globe (six papers from the six channels from each station each day) producing an abundance of high quality data for research. A total of some 4 million seismographs[3] were produced by WWSSN, being irreplaceable historic seismic data, particularly useful for evaluating historical earthquake risk/hazards.[4]



Components of the WWSSN. Upper left - Sprengnether LP seismometers, Upper right - Benioff SP seismometers. The galvanometers & photographic paper recording drums in foreground. The electronics console centre rear, contains timing system, calibration circuits, gain controls & power supply.

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

The Adelaide University entered into agreement with C&GS to operate a WWSSN station and in April 1962, C&GS installed and commissioned a WWSSN station in the Mt Bonython Seismic Observatory (located near to Mt Lofty, South Australia) with the Station Code of ADE.[5]

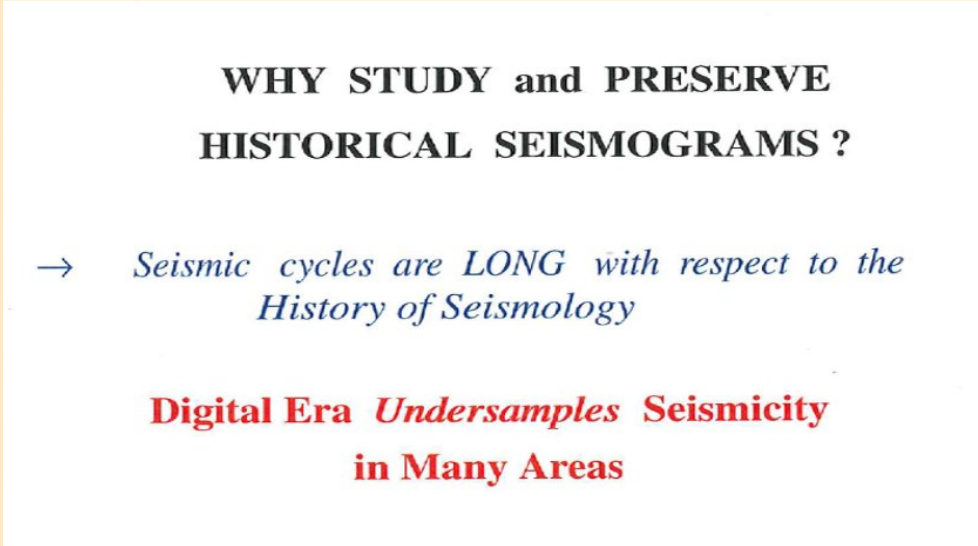
The WWSSN equipment at ADE was eventually superseded by the digital age of seismology and fell into disuse. Ownership passed to the South Australian Government Seismological Department, and upon the closure of this government department towards the end of 2016, the SA State Government formally transferred ownership of the WWSSN equipment to SAA.[6] The transfer including three Benioff Short-Period seismometers and three Sprengnether Long-Period Seismometers, which members of SAA removed from the Mt Bonython seismic vault in April 2017.

Plans for recommissioning of historic seismometers

The SAA intends to re-commission their set of three Benioff and three Sprengnether historical WWSSN instruments. The only other known remaining set of six functional WWSSN instruments are at the Albuquerque Seismological Laboratory, New Mexico, USA.[7]

But what is the reason to re-commission 55 year old seismometers, when modern force feedback seismometers are supposedly just so more advanced?

As Professor Emily A. Okal[8] says, *"The youth of seismology as a science, compared to the typical duration of seismic cycles, results in a relative scarcity of records of large earthquakes available for processing by modern analytical techniques, which in turn makes archived datasets of historical seismograms extremely valuable in order to enhance our understanding of the occurrence of large, destructive earthquakes."*



"Historical Seismograms – An Endangered Species"
Webinar November 2015, Professor Emile A. Okal
Dept. of Earth and Planetary Sciences, Northwestern University
Evanston, IL 60208 USA.[9]

So the approximately 4 million WWSSN daily seismographs recorded between 1961 and 1978 represent a significant portion of instrumentally recorded seismological history, invaluable in determination of long term seismic hazard evaluation. And as these historic WWSSN analogue seismographs are progressively digitized then there is the need to preserve WWSSN instruments as historic reference instruments that actually recorded these seismographs.[10]

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

Re-commissioning SAA's Sprengnether Long-Period Vertical on the seismic pier of The Peters Seismological Observatory (TPSO).

When SAA's Sprengnether No. 2165 was first commissioned in April 1962 at the ADE Mt Bonython WWSSN station, it was the age where the most innovative technology available for recording quakes, was to connect the seismometer's coil output, to a sensitive galvanometer located in a dark room, and where a beam of light was reflected off the mirror of the sensitive galvanometer onto a rotating drum of un-developed photographic paper. As some members of SAA recall, it then required the daily changing of these six photographic papers in the dark room, which papers then had to be developed in an adjoining dark room with chemicals, and then posted off to USA. Apart from being a physically labour intense process, the resulting magnification of the WWSSN was far, far less than the magnification available from today's digital seismometers.

"By modern digital standards, the WWSSN was a very low dynamic range system. As Jon Peterson and Bob Hutt point[s] out …. to have an analog WWSSN system equivalent to today's recorders would require a photographic recording drum 17 kilometers (km) wide with a distance between the galvanometer and drum of 54 km!"[11]

The nominal magnification of WWSSN station ADE was 25,000 for the Short-Period instruments and 750 for the Long-Period instruments.[12] Calibration pulses (that were themselves accurately calibrated by reference to periodic "weight lift" tests off the instrument's "proof mass") were injected every day onto every seismograph paper, and were used to give the actual magnification for that instrument (and its galvanometer).

But just how does SAA's 55 year old Sprengnether Long-Period Vertical seismometer perform, if its output is fed not onto photographic paper on a drum in a dark room, but its output is fed into an EchoPro digitizer.

SAA's Sprengnether Long-Period Vertical seismometer (Serial No. 2165) from the de-commissioned WWSSN ADE station. Now operational on the seismic pier of TPSO. With its period set at 20s, it is optimal for recording Love and Rayleigh surface waves.

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

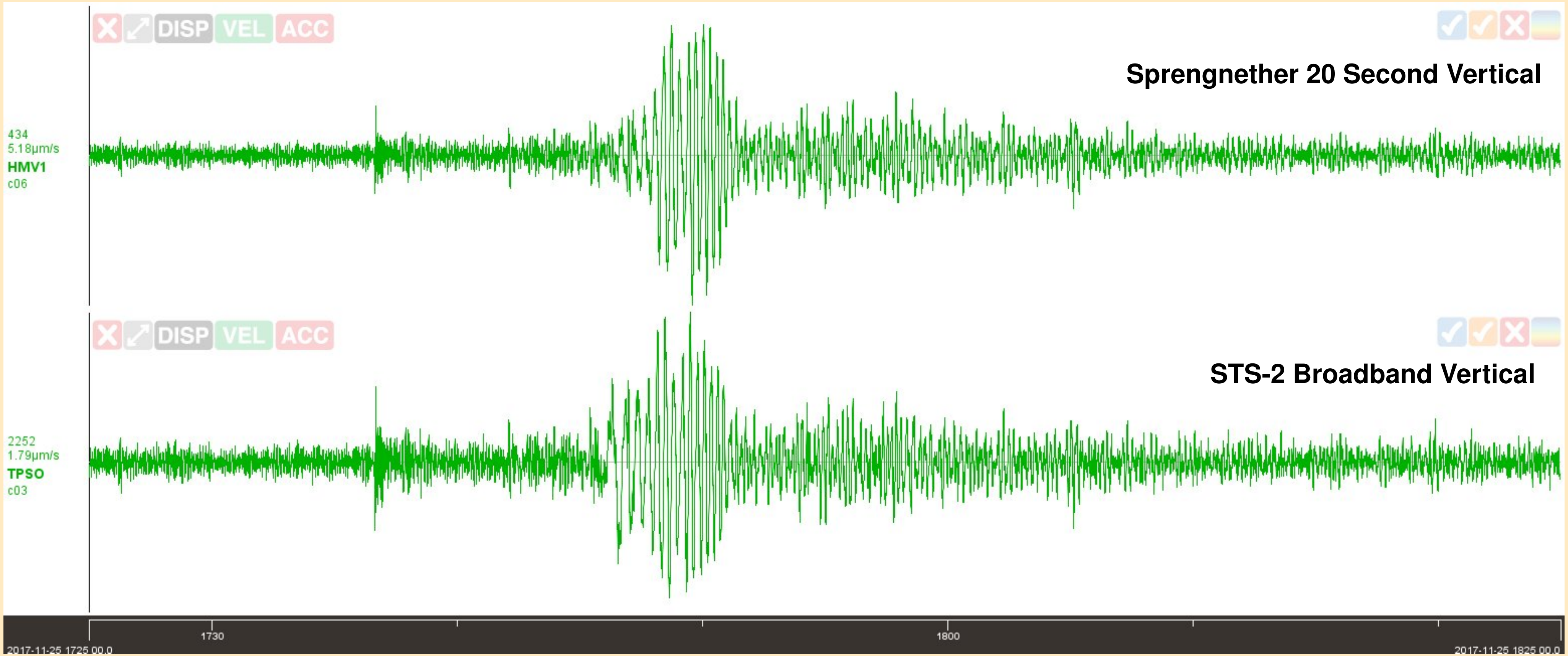


Figure 1: One hour long seismograph (Vertical Component only) from temperature stable seismic vault of TPSO which had not been opened for at least two weeks. Traces commencing at 17:25:00 UTC, 2017-11-25

The upper trace was recorded by SAA's Sprengnether Long-Period Vertical (20 second) seismometer S/N 2168, [HMV1 C06]
The lower trace was recorded by STS-2 force-feedback broadband triaxial seismometer S/N 99712, [TPSO C03] on loan from the ANU. Canberra.
Showing waves from New Caledonia M5.8 quake of 2017-11-25, 17:30:01, epicentre some 3,280 kms to the ENE. P wave arriving at 17:36:40.

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

The subtle differences seen in the two traces in Figure 1 requires 'quantitative' statements amounting to more than just acquiring a record and 'looking at it'. (And more than just one famous physicist has stated 'for the record': *"If what you're doing cannot be 'measured', then it's not true science"*).[13]

Because the records of the Sprengnether whilst being on the pier of TPSO, have been stored digitally (unlike the time of the WWSSN using light beams reflected off mirrors of sensitive galvanometers onto rotating drums of photographic sensitive paper) then this now allows SAA for the first time to conduct a whole new world of analysis between these two instruments using frequency-domain considerations as well as using conventional time-domain considerations.

Sprengnether Long Period (20 Second) Vertical HMV1 [C06]

SAA's passive Sprengnether Vertical instrument uses a Faraday sensor (coil/magnet) which produces an output proportional to ground velocity.

It suffers from the limitation of having a conventional mechanical suspension using strip hinges, and a La Coste Zero Length Spring. Which conventional mechanical suspension engenders irregularities into the motion of the "Proof Mass" when the "Proof Mass" moves up and down relative to the instrument case. "Proof Mass" weighs 12 Kg's.

The Sprengnether also suffers from the non-linearity of the output of the coil as it moves inside the magnet, and, *"… appears to be limited by the granular nature of magnetism to something like 10^{-10} m."* [i]

That said, the response of the Sprengnether is able to be well calculated using standard physics, being a constant response to the Velocity of the ground motions, until the frequency of ground movements falls below its natural frequency, where the response then falls away at 20dB/decade.

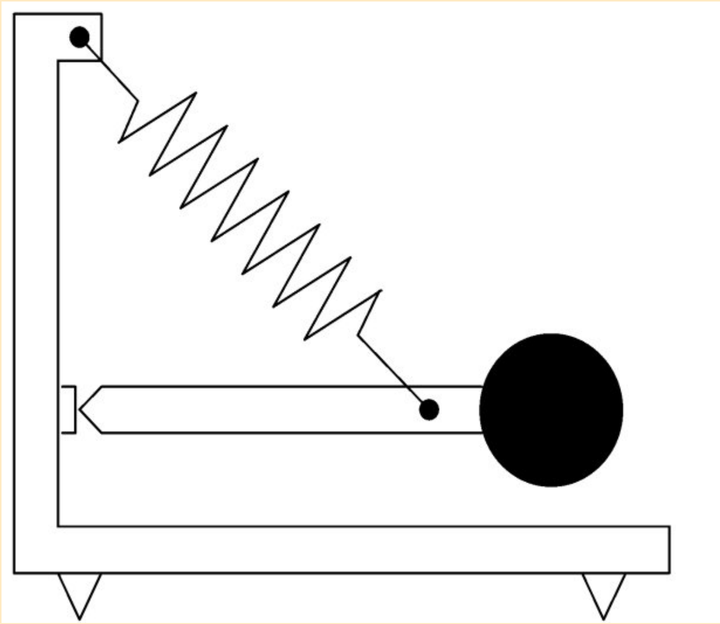


Figure 2: Schematic of the conventional mechanical suspension of the SAA's Sprengnether Vertical seismometer - strip hinges and a La Coste Zero Length Spring.[14]

If you want to know a little more about the work of Paul Hutchinson and The Peters Seismological Observatory at Hindmarsh Valley, SA take a look at a short video produced by Adm Pascale on the SRC YouTube channel at the following link:

https://www.youtube.com/watch?v=ZayEvWsNu6I

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

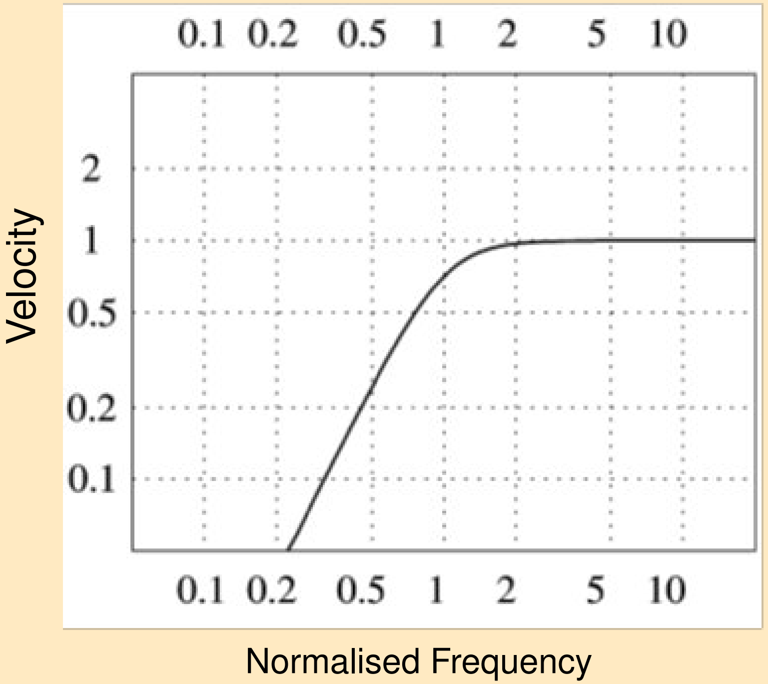


Figure 3: Response Curve of a Faraday sensor (coil/magnet) equipped seismometer, like the Sprengnether Vertical. The normalised frequency is the signal frequency divided by the eigenfrequency (corner frequency) of the seismometer. After Wielandt.[16]

STS-2 Broad Band Force Balance (0.02 to 120 Seconds) TPSO C03

STS-2 measures acceleration but outputs velocity. The STS-2 instrument, which uses the Force-Balance principle, *"…generate[s] a feedback force that is proportional to ground acceleration."*[17]

Erhard Wielandt the co-designer of the Force-Balance STS-2 seismograph[18] says, *"For broadband seismic recording with high sensitivity, an output signal proportional to ground acceleration is unfavorable."* 19

He goes on to say, *"What we need is … a high-pass response in terms of ground velocity, like that of a normal electromagnetic seismometer* [coil/magnet seismometer just like SAA's Sprengnether] *but with a lower corner frequency."*[20]

That is the STS-2 feedback force that is proportional to ground acceleration, is time integrated to then give the STS-2 output that is, *"… flat to velocity over a certain passband."*[21]

That is, the output of the modern force feedback seismometer has been designed to give a velocity output response over a certain pass band, as in Figure 3 above, **the same generic velocity output response as SAA's historical Sprengnether.**

Why? Why was the native output of the STS-2, being acceleration, converted to velocity output. This was done no doubt, to ensure the new force feed back seismometers were readily accepted by the seismological community that for some three quarters of a century had been using instruments of conventional coil/magnet design giving velocity output.

Advantage of an astatic leaf spring suspension in a Force Feed Back seismometer.

In the modern force feedback seismometer, *"The inertial force is compensated (or 'balanced') with an electrically generated [feedback] force so that the seismic [proof] mass follows the motion of the frame."*[22]
This is called an astatic suspension (Wielandt 1975)

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

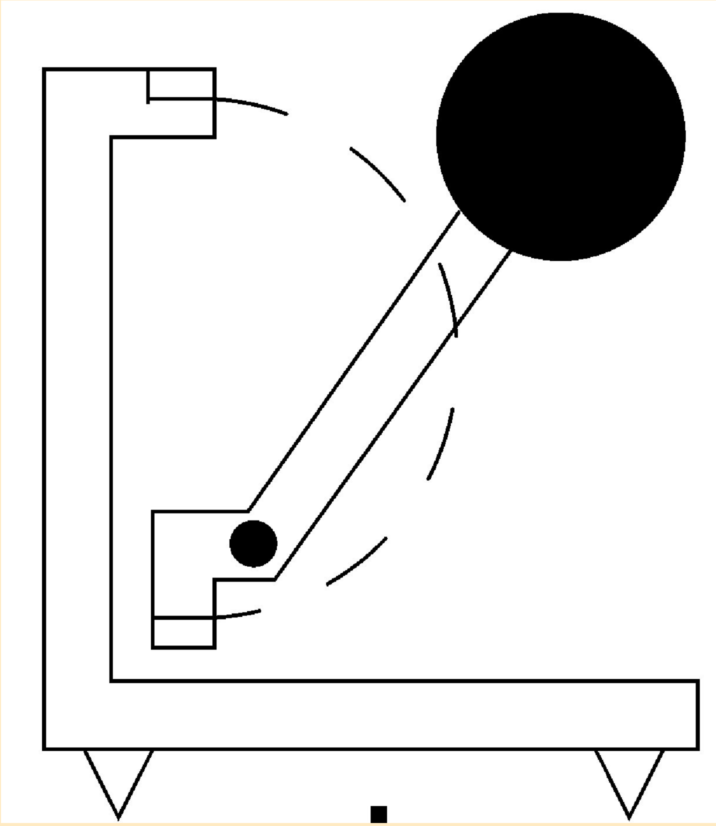


Figure 4: Schematic of STS-2 leaf spring astatic suspension.[23]

The "Proof Mass" in an astatic leaf spring suspension follows the motion of the frame of the instrument, thereby giving a decided advantage to the Force-Balance instrument being that the acceleration of the instrument case is converted, *"...into an electric signal without depending on the precision of a mechanical suspension."*[24]

Disadvantages of the Force Feed Back system.

However, the Force-Balance seismometer has some limitations, including,

- *"... some small relative motion [of the proof-mass] must remain because otherwise the inertial force could not be observed."* [25] ,
- *"Due to unavoidable delays in the feedback loop, force-balance systems have a limited bandwidth."* [26],
- Phase Response is not flat over stated bandwidth.
  STS-2 S/N 99712 has a +45 Degrees Phase Response at 15 mHz (67 seconds) thru to a -45 Degrees Phase Response at 40 Hz 0.025 Seconds)[27]

Even with these limitations, Wielandt says, *"In fact, electronic broadband seismometers, even if their actual electronic circuit is more complicated …. follow the simple theoretical response of electromagnetic seismometers* [that use a Faraday coil/magnet sensor] *more closely than those ever did."* [28]

The *"… simple theoretical response.."* he was referring to is what is shown in Figure 3 above.

Figure 3 above being an electromagnetic seismometer [that uses a Faraday coil/magnet sensor] like SAA's Sprengnether.

The Challenge.

But does it? Does the electronic broadband seismometer, does the STS-2 *"… follow the simple theoretical response of electromagnetic seismometers* [as shown in Figure 3 above] *more closely than those* [Sprengnethers] *ever did."*

SAA's historic set of Benioff Short Period & Sprengnether Long Period seismographs.

In the **next SAA Newsletter**, the question will be answered, does the modern force feed back STS-2, having the advantage of an astatic leaf spring suspension and complex electronics and having those limitations as discussed, follow the simple response curve of Figure 3 more faithfully than does SAA's historic passive Sprengnether seismograph with its simple coil/magnet sensor but having the disadvantage of a mechanical suspension system.

A thorough analysis using frequency domain considerations and using new seismic analytical tools to what has typically been a time-domain-only consideration, will allow for a greatly improved potential to 'SEE' new things. The 21st century has brought means for improved understanding of seismology, as pertains to the physics 'elements' of its foundation. There are a variety of important 'technological' inventions, that only recently came into existence. They make for brand new possibilities, with which to unlock additional 'mysteries of the universe'.

So, is SAA's 55 year old historic passive Sprengnether really up to the challenge?

Paul Hutchinson - 19 January 2018

[1] For more information on the Berkner Panel and related activities, please refer to Bolt (1971) and Romney (2009)
[2] World-Wide Standardized Seismograph Network: A Data Users Guide By Jon Peterson and Charles R. Hutt
[3] 1. Background page 3 second para
[4] Foreword Chuck Langston Para 4, Page iii
[5] Table 2.1 Page 5
[6] Dept of Premier and Cabinet "Declaration of Surplus Seismological Equipment Transfer" Ref 2017D026646 dated 7th November 2017.
[7] David (Dave) Wilson, Scientist-in-Charge, Albuquerque Seismological Laboratory, United States Geological Survey
[8] Professor Emily A. Okal
[9] Historical Seismographs: An Endangered Species
[10] Foreword Chuck Langston Para 5, Page iii
[11] Foreword Chuck Langston Para 4, Page iii
[12] Table 2.1 Page 5
[13] Lord Kelvin
[14] Figure 5.6 - New Manual of Seismological Observatory Practice (NMSOP-2) 5.3.2.
[15] Erhard Wielandt NMSOP-2 5.3.9..
[16] Figure 5.3 NMSOP-2 5.2.8.
[17] Erhard Wielandt NMSOP-2 5.4.1.
[18] Wielandt, E., and Streckeisen, G. (1982). The leaf-spring seismometer: Design and performance. Bull. Seism. Soc. Am., 72, 2349-2367.
[19] Erhard Wielandt NMSOP-2 5.4.3.
[20] Erhard Wielandt NMSOP-2 5.4.3.
[21] Erhard Wielandt NMSOP-2 5.4.3.
[22] Erhard Wielandt NMSOP-2 5.4.1.
[23] Erhard Wielandt NMSOP-2 5.4.1.
[24] Figure 5.7. NMSOP-2 5.3.2.
[25] Erhard Wielandt NMSOP-2 5.4.1.
[26] Erhard Wielandt NMSOP-2 5.4.1.
[27] "Phase Response" chart, Page 20, dated 27 th March 1998 - STS-2 Manual
[28] Erhard Wielandt NMSOP-2 5.4.3.

SAA member activities

PSN Seismology on a Raspberry Pi - Single Board Computer Workshop

The Public Seismic Network (PSN) is largely dependent on digitisers and software from Larry Cochrane at Webtronics (USA). SAA members operating Larry's hardware usually use personal computers or notebooks to display and record seismic data, and to send their data out for wider dissemination. The Raspberry Pi (RPi) is a small, low power device capable of running Webtronics WinSDR software, offering significant purchase cost and power efficiency savings over conventional PCs and notebooks.

As you might expect, transitioning from a familiar Windows operating system environment to the RPi software equivalent is not for the faint of heart and it takes considerable time and effort. On Thursday, Jan 4th 2018, a hastily convened workshop was held at David & Heather Loves house at Payneham, SA.

Blair and I were tasked with bringing some demonstration hardware and the plan was to go through the process of loading software and configuration of the RPi to produce a functional seismic monitoring system in less than about five hours. A draft amalgamation of the late Dale Hardy's RSUW website RPi set-up instructions had been produced, as a work-in-progress guide and away we went. Between the downloads and updates, we discussed hardware requirements, equipment costs, software costs and how the software layers interacted.

Around 6:30pm (ACST) we stopped to eat, just as the Exagear Desktop download was started, courtesy of the blinding connection speeds provided by the NBN. Everyone enjoyed the pizza we had for dinner, catching up with old friends and putting faces to names familiar only by emails. Vic Dent introduced us to Paul Harris's latest rsn_client (V31), which allows the RPi to report in direct mode (no WinSDR) back to the Australian Centre for Geomechanics.

By the end of the workshop we had Exagear Desktop downloaded, updated and ready to activate with the all important software key but sadly, we were out of time.

The consolidated and updated Seismic_RPi set-up .pdf is now available. With Vic's assistance, both Gary Gibson (S88) and myself (MTON) have successfully deployed RPi seismic monitoring systems using the direct mode method and there are several more systems close to operation, at time of publication.

Peter Gray - SAA Editor

Left to Right

Heather Love
David Love
Jim Deer
Peter Gray
Colin Love
John Duffield
Blair Lade
Ian Anderson
Paul Hutchinson
Saide Gray
Gary Gibson
Vic Dent