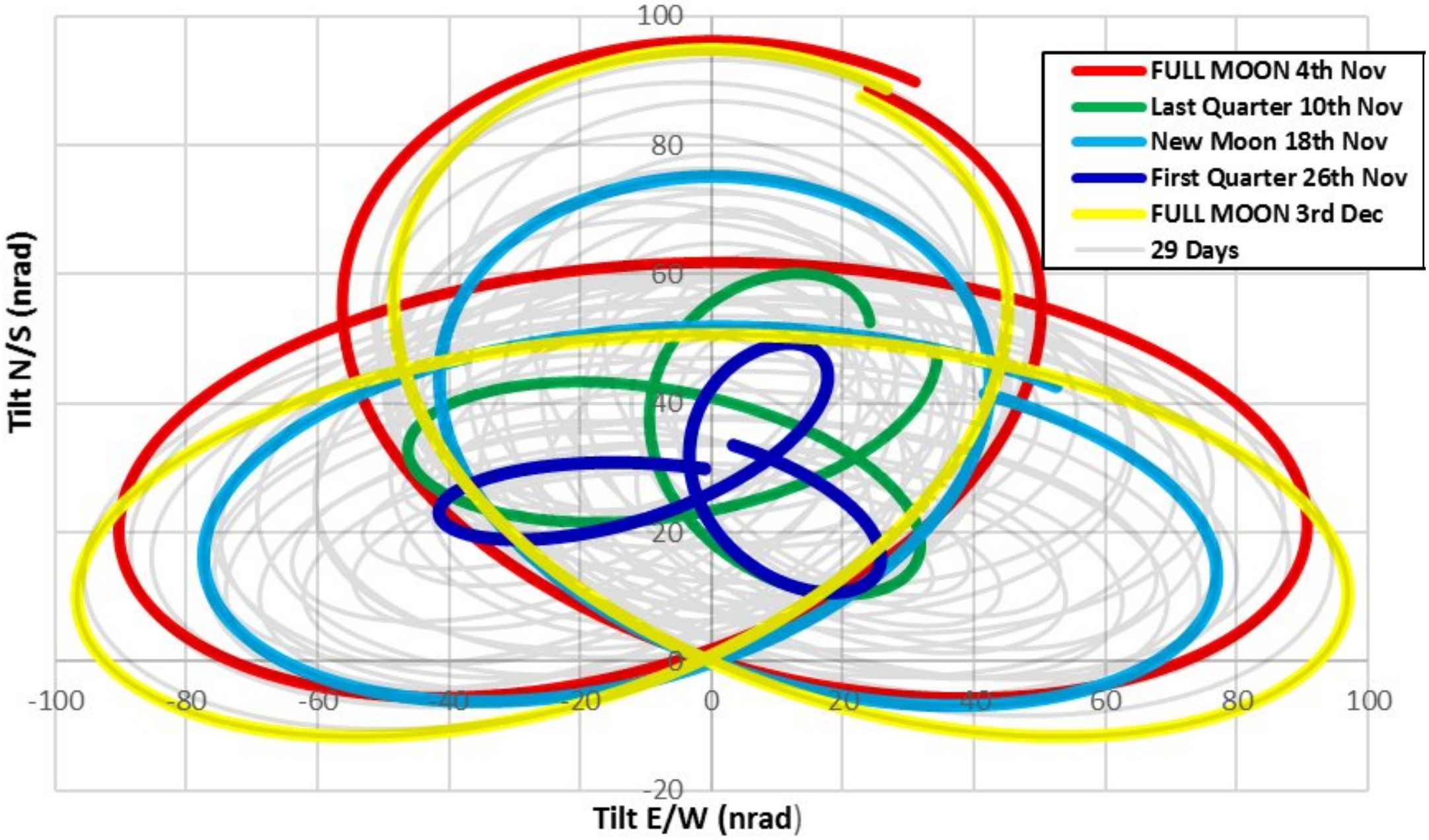
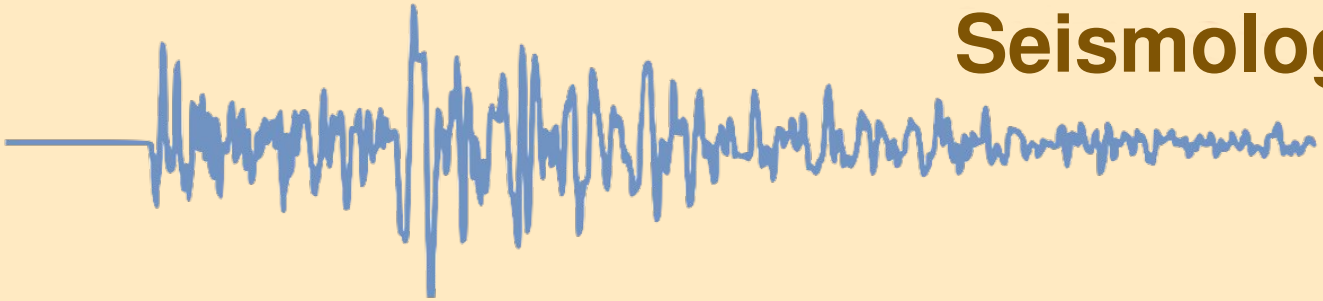
Newsletter of the Seismological Association of Australia Inc. Mar-Apr 2018





Seismological Association of Australia Inc.

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

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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
Summer's come and gone and winter's just around the corner, time to do some maintenance on our sites before the wet weather sets in. While you're out doing some preventative maintenance, consider the following:

PNG area ~460,000 square km, population 8.3 million people and 13 instruments.

South Australia ~ 1 million square km, 1.7 million people, over 30 instruments and we don't get 'earthquakes'!

There are more PSN (privately owned) seismic instruments in Australia than there are instruments in PNG.

Australia sends seismic team to PNG to deploy portable instruments.

'Seismologists Kevin McCue and Gary Gibson (both well over the age of 60) installed … 6 instruments'

continued on next page

A word from the Chairperson
continued

Why aren't the young seismologists doing this? Don't we have any?

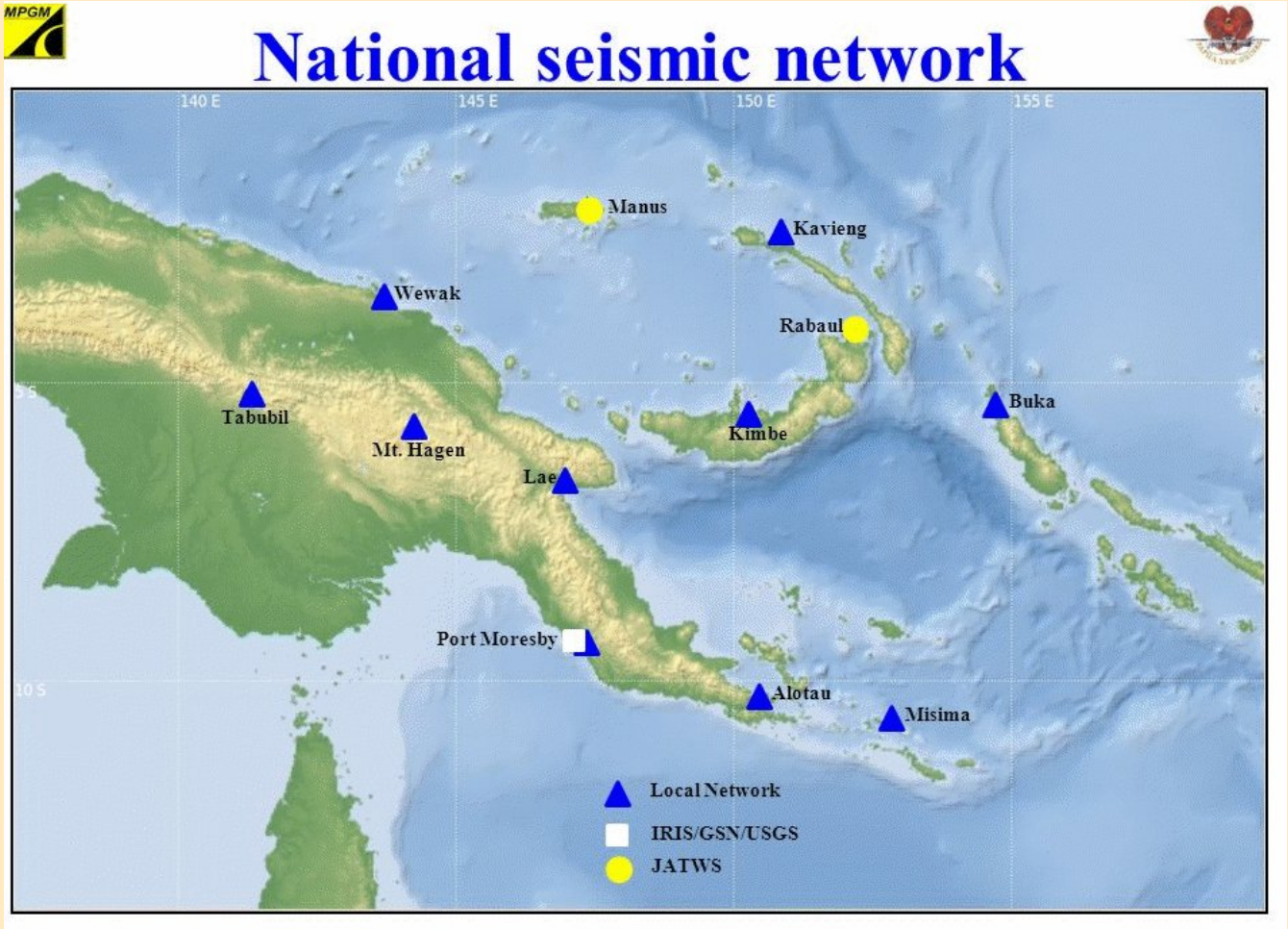
The average age of SAA members is over 60. Where are the young amateur seismologists?

Isn't Seismology sexy enough to draw young people to it?

National Science Week is August 11th to the 19th

The SAA will have a booth at the Wayville Showgrounds in South Australia during the 'big event'. With over 30,000 people attending over three days, we have to enthuse younger people into Seismology. Your participation in this event could be the trigger for a new generation of seismologists both professional and amateur.

Blair Lade
Chairman SAA



PNG Seismic Network - operational status unknown

SAA News & rumblings

SAA Newsletter on Dropbox

Due to this edition of the SAA Newsletter being a little large, you probably had to download the file from Dropbox. I am happy to acknowledge my appreciation to all of our contributors for the articles presented and in particular, Prof. Randall Peters and Paul Hutchinson for two new and original papers that you will find, beginning on Page 19 & Page 27 of this newsletter. Should you want to download the "papers" in their original published form (for clarity of image detail) the following two links will allow you to do so.

Order Out of Tidal Force Complexity

Foundations of Spectral Analysis based in the Physics Definition of Power

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. You do not need to have a Dropbox account to access these files.

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.

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 held a members meeting on the 20th of March to discuss ideas, suggestions and seek volunteers to participate at this event. Our experienced event guru, John Mignone was able to provide some guidance to an eager assembly of about 14 members. The meeting concluded with a healthy list of planning tasks, including development of engaging and educational activities/exibits. Should you be able to assist in whatever way, please contact the SAA Treasurer, Joe Grida at your earliest convenience

Atlas of the Underworld

Michael Andre Phillips of Coonabarabran, NSW has sent us a link to another gem of a website and provided a bit of a review of its content. "It is a global atlas of subducted tectonic plate (via earthquake tomography), and the thing I personally find remarkable is how deep and how long lived these plates are, occasionally extending to depths taking them near the core. I had thought that subducted plates simply melted when they were not too deep, and homogenised with the mantle. Apparently not, and they take a lot longer to fully melt, and at much greater depth." Thanks Michael, there is a link to it above

On the cover page of this issue - The daily choreography of the crust we stand upon.

Simple Theoretical modelling of the daily tilting of the Earth's crust at The Peters Seismological Observatory, Hindmarsh Valley, South Australia by Dr Walter Zurn from the Black Forest Observatory, Germany.

No ocean effects. No local effects.

TPSO - Solid Earth Tides - Zurn Predicted Tilt expressed in nanoradians (nrad).
1 nrad = approx. 0.209 milliarcseconds

Highlighted periods - Moon over Meridian till moon again over Meridian. (Being an average time of 24 hours, 51 minutes between Meridian crossings)

First Meridian crossing occuring at 2017-11-03 14:00 UT

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.

In the 1950's, a priest from Warwick (Qld) was inspired to discover cyclone related microseismic research on his home built instruments

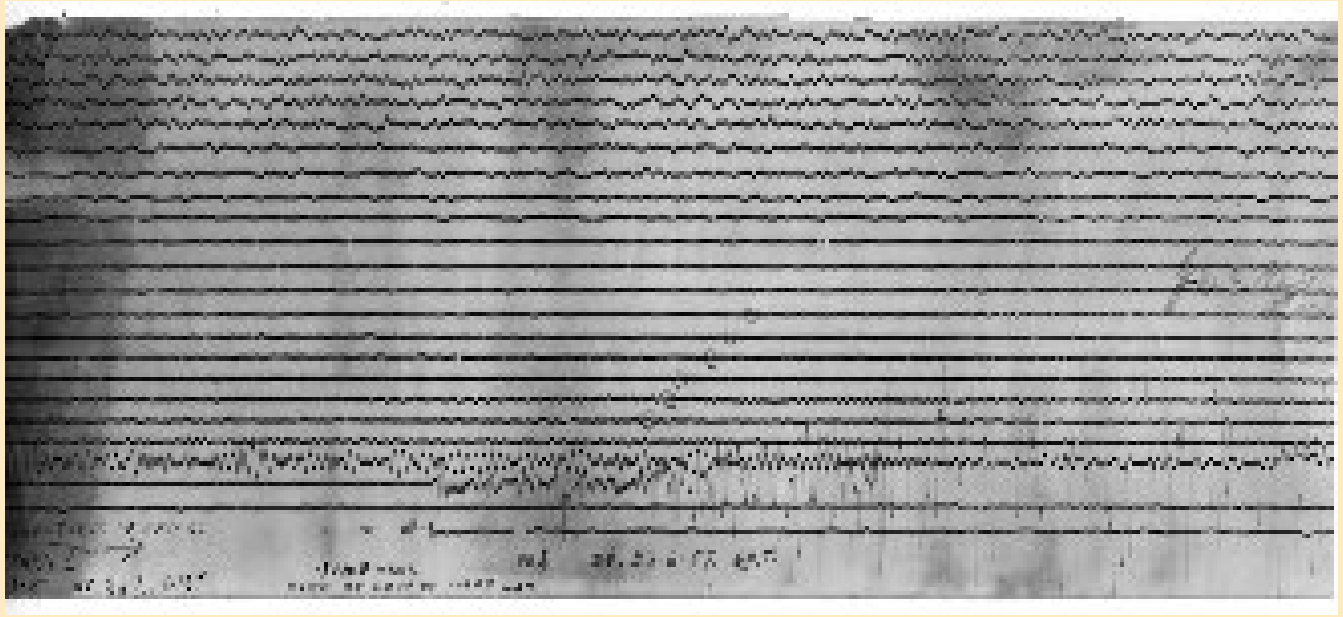
This is a story about seismology and inspiration, and how it excites the minds of curious earth watchers.

The Seismological Association of Australia is nearing it's first year of operation. It surely is an example of inspiration that is re-igniting amateur and professional interest in communicating new ways of doing science using the Citizen Scientist. Let me tell you a story about another such thread of inspiration, that has flickered in the restless minds of Queensland earth watchers. I am sure you all can recollect what got you involved in seismology. Please document it or drop me a line about that.

During my attempts at curating and revitalising The University of Queensland Seismograph Stations' (UQSS) Collection (1935-present), I came across the 1957 correspondence and 2 seismograms from the late Father Joe McKey from St Mary's Church in Warwick, Queensland. One of these seismograms appears below, and shows how well the 1957 Magnitude 7.1 BIAK (Indonesia) earthquake was captured on Fr. McKey's home built "Milne Shaw" seismograph. The other recorded phenomena to note is the enlarged microseismic background noise at the top of the seismogram, for which his research is recognised.
This was a "Tropical low moving SE from inland NSW, strong high in Tasman Sea, strong NE-E gradient. Complex lows formed near coast".

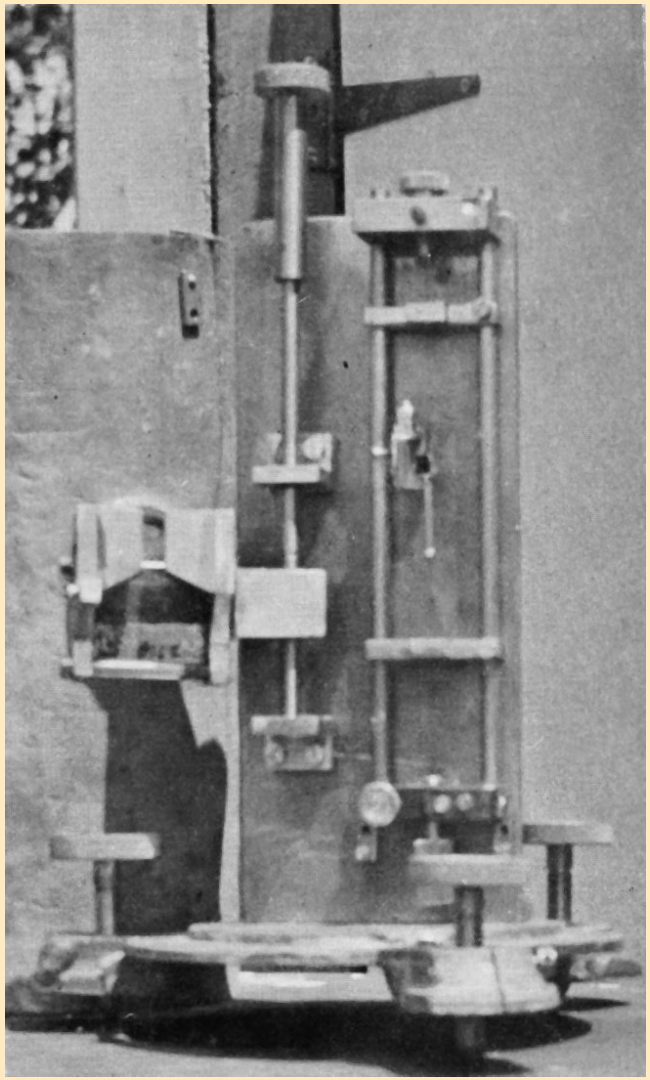
What is noteworthy about this Roman Catholic priest is his inspired and persistent search for mechanical and scientific knowledge. In spite of a long-term illness (possibly T.B.), he qualified as a small aircraft pilot, gained a Diploma of Engineering by correspondence (Sydney), purchased a lathe and then made 5 recording seismographs. He was a member of the Queensland Astronomical Society (1940).

Both the British astronomical Association (1951) and American Society of Seismologists awarded him membership, in "recognition of his valuable work in microseismic research dealing with the recording of long distance cyclones on seismographs." (Ansell, 1983)



1957 annotated seismogram from E-W "Milne Shaw" model built by Fr. Joe McKey, Warwick (Q'ld). M 7.1 - Biak region, Indonesia
1957-06-22 23:50:35 UTC 1.723°S 136.592°E 59.1 km depth

In the 1950's, a priest from Warwick (Qld) was inspired to discover cyclone related microseismic research on his home built instruments



Wood-Anderson Seismometer by Fr. J. McKey

In L.J. Ansell's biography of Fr. Joe McKey there is a description of the seismograph observatory that he had built:

"The building of the seismograph and its accurate timing took years of patient experimentation. It is housed in a home-made cement vault In Father McKey's backyard in Locke Street, a foot below bedrock level. Today he has 2 complete sets of instruments in two separate vaults. Each would cost approximately a thousand pounds if obtained from an instrument firm.

To the layman, his seismographs look mysterious and rather crude contraptions, built of preserves tins, rough bits of timber, Masonite and brass sheets. Each instrument is resting on a home-made rock block, separated from the concrete floor by a bitumen layer.

But under the crude looking covering is a very sensitive instrument – in fact so sensitive that a single cigarette paper dropped on it deflects its beam on the chart. The seismograph is actually a pendulum arm, hinged on a jewel base and brought back to its normal position after each deviation by an oil damping system.
(extract (p100) ***Joseph McKey Priest-Scientist-Historian*** *by L.J. Ansell, (ISBN 0 9593145 3 9) published by The Diocese of Toowoomba (Aug 1983))"*

Significant to this story is the UQ Dept. of Geology Research Assistant, Mr Albert Crawfoot who, in 1953, "was able to give Fr. McKey much of his design information for constructing a seismograph" (Ansell, p. 101). Mr Crawfoot also corresponded with another Queensland amateur seismologist (Mr Arthur Hill in Dimbulah, North Queensland) who also built a seismograph.
It is possible that both of these men were inspired by a small article in the Courier Mail (21 Mar 1952)

<u>Tremor Cult May Spread.</u> Mr Albert Crawfoot, scientific assistant at the Queensland University Seismograph Station believes a cult of earthquake reading may develop in Australia. Since his home-made 5 pound(£) seismograph favourably recorded the Japanese earthquake early this month, Mr Crawfoot has had several inquiries from people in Melbourne and North to Cairns. He intends sending them directions and photographs. He can visualise tiny seismograph stations dotted about the Commonwealth if 'earthquake reading' becomes a vogue.
Mr Crawfoot said this would be beneficial scientifically to Australia.

This surely then is the catalytic sequence of inspiration that an Op-Ed columnist for the New York Times wrote about in 2016:

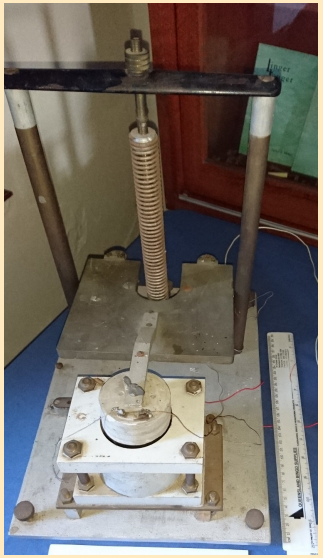
In the 1950's, a priest from Warwick (Qld) was inspired to discover cyclone related microseismic research on his home built instruments

Inspiration does not happen to autonomous individuals. It is a beautiful contagion that passes through individuals. The word itself comes from the Latin inspirare, meaning "to breathe into." One inspiring achievement – say the space program – has a tendency to raise the sense of possibility in others – say, a little boy who dreams of being an astronomer. Then the one who is inspired performs his own feats and inspires others, and so on down the line.

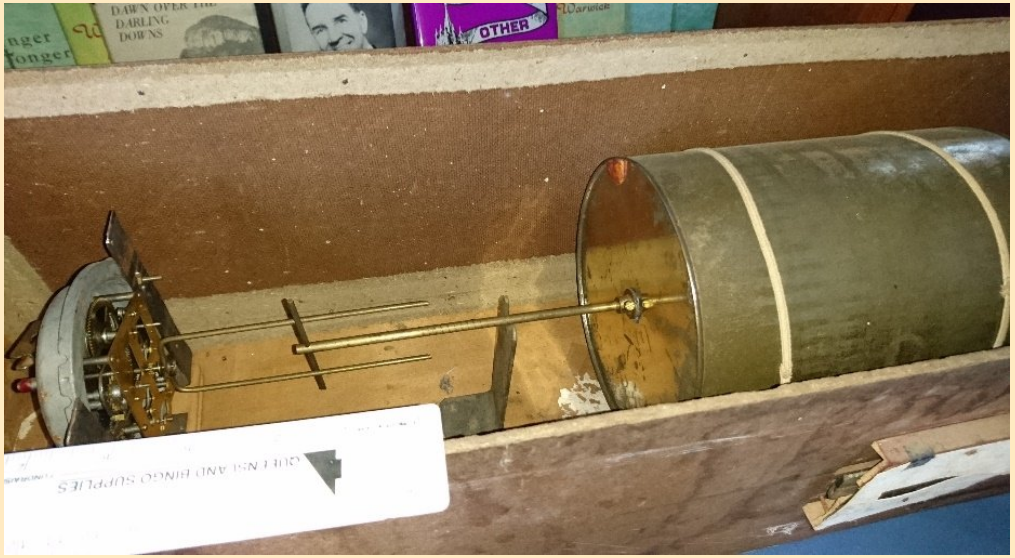
http://www.ny.times.com/2016/04/15/opinion/what-is-inspiration.html

The Warwick community holds Fr Joe McKey in such esteem, today, that they have established a small museum in the St Mary's Church, Warwick. The above photos come from that collection display. The inspiration went further. In 1989, Warwick community interest was triggered into funding, constructing and running a small commemorative seismograph station in conjunction with a research project being led by the Late Dr Jack Rynn, who was a Research Fellow at the UQSS. A newspaper clipping on the next page explains that.

Where did this inspirational thread grow from? In the 1969 University of Queensland gazette (V69, p.11) we get a sense of the inspired work, investment of time and effort and controversy that set the fuse at the University of Queensland.



Wilson Lamerson Seismometer



Milne Shaw drum recorder

Other instruments built by Fr Joe McKey (Images courtesy St Mary's Administrator)

"In 1946 Owen Jones became the officer-in-charge of the seismological station that had been established through the efforts of the head of the Department of Geology and Mineralogy, the late Professor W.H. Bryan. Owen Jones greatly developed the station, and was responsible for the expansion into a two-station network with the installation at Charters Towers. This came from his application for International Geophysical Year funds. As a result of his devoted work, the seismological records coming from the Department have long been recognised as consistently of high quality and are of world-wide significance. Owen Jones and his collaborators were pioneers in the highly controversial use of microseisms for locating and keeping track of cyclones. He was eventually able to get government support for the installation in North Queensland of an array of seismographs for this purpose.

The manning of the station and the correlation of data became an increasing burden. Owen Jones (with one half time assistant only) did this work 365 days a year for many years.

In the 1950's, a priest from Warwick (Qld) was inspired to discover cyclone related microseismic research on his home built instruments

Seismographic diaries record 1961 'quakes

By JANN GEORGE

DIARIES detailing seismic activity recorded by Father Joseph McKey are being examined by members of the committee involved with the establishment of the seismograph station at Warwick.

Spokesman, Mr Stuart Watt, said he had already found two entries indicating Father McKey's hand-built Warwick-based seismograph had detected earthquakes in 1961.

He said one entry indicated seismic activity in that year on March 28 near the Solomon Islands and another on May 22 with the epicentre 20 miles off the NSW south coast.

"When seismographs are logged, two main types of waves are recorded—P (primary) and S (secondary). These are different types of waves which are so named because the P-waves are faster and arrive before the slower S-waves," Mr Watt said.

The P-S time delay increase as the earthquake distance increases.

The diary entry on March 28 indicated Father McKey was able to read off a P-S time of 5¾ minutes.

He then scaled that to 4300km, or 30 degrees around the Earth, and estimated that the earthquake occurred in the earthquake active area Papua New Guinea.

"An individual seismograph only tells the distance to the earthquake, but by using all measurements from three seismographs, position, depth and magnitude can be decided," Mr Watt said.

Mr Watt said Father McKey's seismograph had the drum recorder next to the seismometer for easy reading.

The new seismograph will be built out of town because of noise problems so reading the instrument could become a problem.

"The solution is to radio the information into town," Mr Watt said.

The diagram below shows the technique to be used.

The signal from the seismometer is fed by cable to an amplifier to an FM radio transmitter and then to an aerial.

The amplifier and transmitter run off a 12 volt car battery but since this will be some distance from power lines, the battery will be recharged by solar plates.

Mr Watt said, for this part of the installation, the committee was still in need of three bags of cement, gravel, 50mm square steel pipe and 10mm aluminium tubing.

He said TAFE students were ready to build the aerial and he appealed to the public for assistance.

"The committee is confident support for this installation will be forthcoming with residents keen to see world-standard seismology station established to the memory of Father Joseph McKey," he said.

SKETCH of proposed seismograph station near Warwick and method of transmittimg data to the city.

Thursday March 9th 1989

Moreover, microseismic work involved attendance and work at the University at one time or another at any hour of the day or night. In addition to these activities, he was deeply involved in considerable work of highly classified nature. This began soon after the war (WW2) and related to detection of nuclear blasts throughout the world.

In recent years the direction of the station has been taken over by (late) Dr. J.P. Webb. However, it was the foresight of Owen Jones that made possible the foundation on which Prof. Wilson has since been able to organise a sound course in Geophysics."

Did the inspiration stop?

What sequence of events has led to the current total community disinterest in seismology by university academics and governments? When did the gyrations of plate boundaries and resultant massive tsunamis become so passé? Has the era of the 3D graphical display media overshadowed the sheer terror that tectonic movements will visit upon us? What other world do we think we are living in?

In Queensland, I can happily report to you that a collegial team of volunteer citizen scientists keep the seismographs running, both in Central Queensland (Dr Mike Turnbull) and at the UQSS. Without official "operational" recognition, I am an acting UQSS honorary seismologist and am ably assisted by volunteers such as Cihan Altinay (legacy systems, software), Dr Dion Weatherley (research and policy), Russ Cuthbertson (Technical problems and BRS gatekeeper) and Dr Steve Hearn (seismograms for students). I also wear the hat of seismogram collection curator and am busy trying to ship 75 years of seismograph station records into the Queensland State Archives before university space runs out.

This article was submitted by:
Colin Lynam, Honorary Seismologist
Earth and Environmental Sciences
The University of Queensland

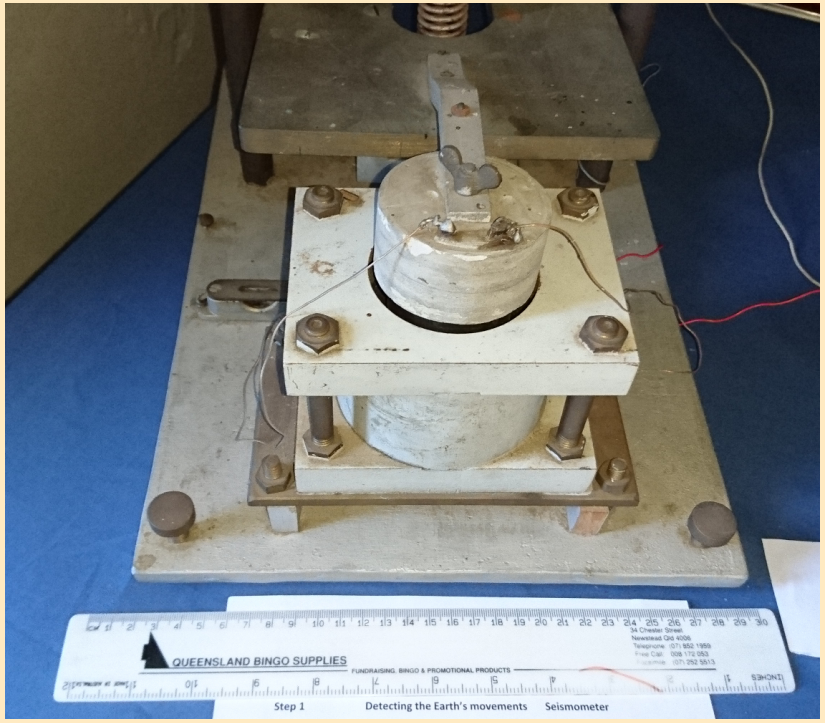
http://www.sees.uq.edu.au/

"Nothing in this world can take the place of persistence.
Talent will not: nothing is more common than unsuccessful people with talent.
Genius will not: unrewarded genius is almost a proverb.
Education will not: the world is full of educated derelicts.
Persistence and determination alone are omnipotent".

Calvin Coolidge (US President)

Further to the previous article "In the 1950's, a priest from Warwick (Qld) was inspired to discover cyclone related microseismic research on his home built instruments"

Colin was able to add some additional images of Fr, McKey's instrument collection. Should you be heading up the New England Highway into Queensland, take some time out and visit the Museum at St. Mary's Church but ring first on (07) 4661 3497 to arrange your visit.



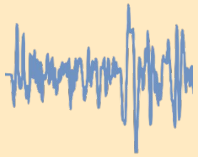
All in a days work

Nambucca

I notice in the paper, and on the radio – there has been a string of felt earthquakes in the Macksville – Nambucca region, north coast NSW. Interesting. I get back to my Sudoku.

A while later David rings up from Adelaide and says "….. gosh Vic, it'd be reeeeallly nice if someone could go up to Coff's Harbour with a recorder. "Well" I say, "I havn't got any gear … but I'll think about it …."

So two days later I am on the train to Newcastle, to visit Dale's son Doug, who has some of his dad's gear. I grab what I can, hope that it will work, and then on the next train to Macksville – or maybe I should get off at Nambucca, next station along - or maybe I should go on to Coff's Harbour, where I am sure there is a hostel. The train stops in Macksville – no hotels in site – not even a house! I ask the conductor if I can go to the next station – no problems (its now 8pm). Nambucca – same story – but the conductor understands. I go on to Coff's and arrive as the receptionist is locking up, but he has a bunk. Great. But first I had better check my gear. About 1am, I think it is working, and off to bed - but there is someone sleeping in my bed!!!



All in a days work

Nambucca

Off to the night manager, who verifies, yes, there is someone in my bed! So I get a private room for the same price. No worries!! Get the train to Nambucca next morning. I unload my gear and look around – lots of bush and not much else. A couple of ladies who got off the train wonder what I am doing. Half an hour later I am setting up my gear at the place of Shirley and her husband, in the garage underneath.

Fast forward 3 weeks, and I am on the train north again, to move the gear from Shirley's place to the high school. I want to get it on-line so I can see the data, and besides, Shirley is tired of the shaking in Nambucca, and is about to give the landlord 2 weeks notice. Shirley said let her know when I was coming, and she would meet me, stay any time. So I sent an email, and later another SMS saying I would arrive 8.30pm. No one at the station. No worries, I unroll my swag as it's a nice night. The next morning I get up and start walking to the school, as it's not that far. A car comes racing down the road, flashing its lights at me. It's Shirley "I just got your SMS - but why did you say 8.30pm when you meant 8.30am??" I say nothing.

To the school and ask for Jennifer Barnett, who was my contact. Sorry, she's not in today. Sorry, so am I considering I have to leave tomorrow night (the doctors are waiting for me with their knives). So they redirect me to Mark the handyman and handy he proves to be. He can solder like I don't know who, build cupboards, rebuild computers and dig trenches. We find a nice spot at the back of the school. But the teacher who runs it is away today sick. The IT department can give me a computer, but it won't be ready till tomorrow. Ho hum – it's going to be another early day.

Tonight I sleep in Shirley's back room (no mosquitoes!!) and next morning to the school again. We spend the day building computers, downloading software, making cabinets to hold a PC, and digging trenches. By 3.30pm we have it ready and going, and I can probably get the 11pm train back to Sydney. Back to Shirley's, and I start to get ready to leave. Check the internet to see the data. Data was posted at 4pm OK, but no new data at 5pm - or then 6pm. Houston, we have a problem. I think back – yes, I remember – Crookwell high school – all the school PCs are programmed to shut down about 5pm. Perhaps I will not get the train tonight, tomorrow's train at 11.45am is the last option.

Next morning off to the school again. Check the PC – it is indeed off. Wait for Mark to arrive, and he logs in for me. It boots – but where is all the software I loaded yesterday?? - there is nothing there !!! Bushy, the IT guy, says it must have done a system update overnight or something. But he can fix it. I reload all the software, and we re-seat the geophone (I suspected something was wrong because of the lack of signal).It's 10.30am and all is done. I cross my fingers, and trust in Mark if more needs to be done. He obviously has got a pretty good handle on it all now. He drives me to the station just in time for the train. And then Shirley turns up with a packed lunch. What lovely people there are in Nambucca.

On the train, and enjoying my lunch. Then the stewardess stands in the aisle in panic, and shrieks "who owns this" pointing to my poor little 20 kg cylinder of steel, a genuine 1956 Willmore Mk II seismometer.

As I write this, I still haven't seen any data since I left at 11am this morning. This still may be a tale with a sad ending.

This article was submitted by Vic Dent, the public face of the ACG's Regional Seismic Network, roving seismic troubleshooter for both amateur and professional seismologists around the country.

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.

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

The Question.
In the last Newsletter, the article describing SAA's historic seismometers asked the question does the modern force feed-back seismometer follow the simple [theoretical] response curve more faithfully than does the historic Sprengnether[1] seismograph.

The answer.
In the area of phase response during long period ground motions from the passage of teleseism surface waves, the historic Sprengnether is shown to easily out-perform three modern force feed-back seismometers.

Differing instrument design.
The STS-2[2], Trillium[3] and Prism[4] on the pier of TPSO, all employ electronic force feed-back to effectively keep the "proof mass" (on the end of an astatic spring-leaf) from moving (in relation to the instrument case). The force required to keep the "proof mass" nearly stationary being stated as being proportional to ground motion Velocity. These three seismometers are optimised to record ground motions typically having periods ranging from 100 seconds to 1/50th second. In addition these three seismometers each employ the Galperin[5] design of three identical orthogonal sensors set at 35.3 degrees to the horizontal which necessitates a transform equation to convert the three differential outputs into the conventional East, North and Vertical components.

The historical Sprengnether Vertical on the pier of TPSO, has a damped "proof mass" suspended by a spring in Zero Length configuration and uses a "passive coil/magnet" to generate the output. The Sprengnether has been set to have optimal response to vertical ground motions arising from the passage of surface waves from teleseisms by having its natural period set to 20 seconds.

The Challenge – a Huddle Test of four seismometers on the same seismic pier.
SAA's historic Sprengnether Long Period Vertical and three modern force feed-back seismometers all on the pier of TPSO, recorded the following Vertical seismographs of a M5.8 New Caledonian quake located some 3,280kms to the ENE.

SAA's Sprengnether Long-Period Vertical seismometer

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

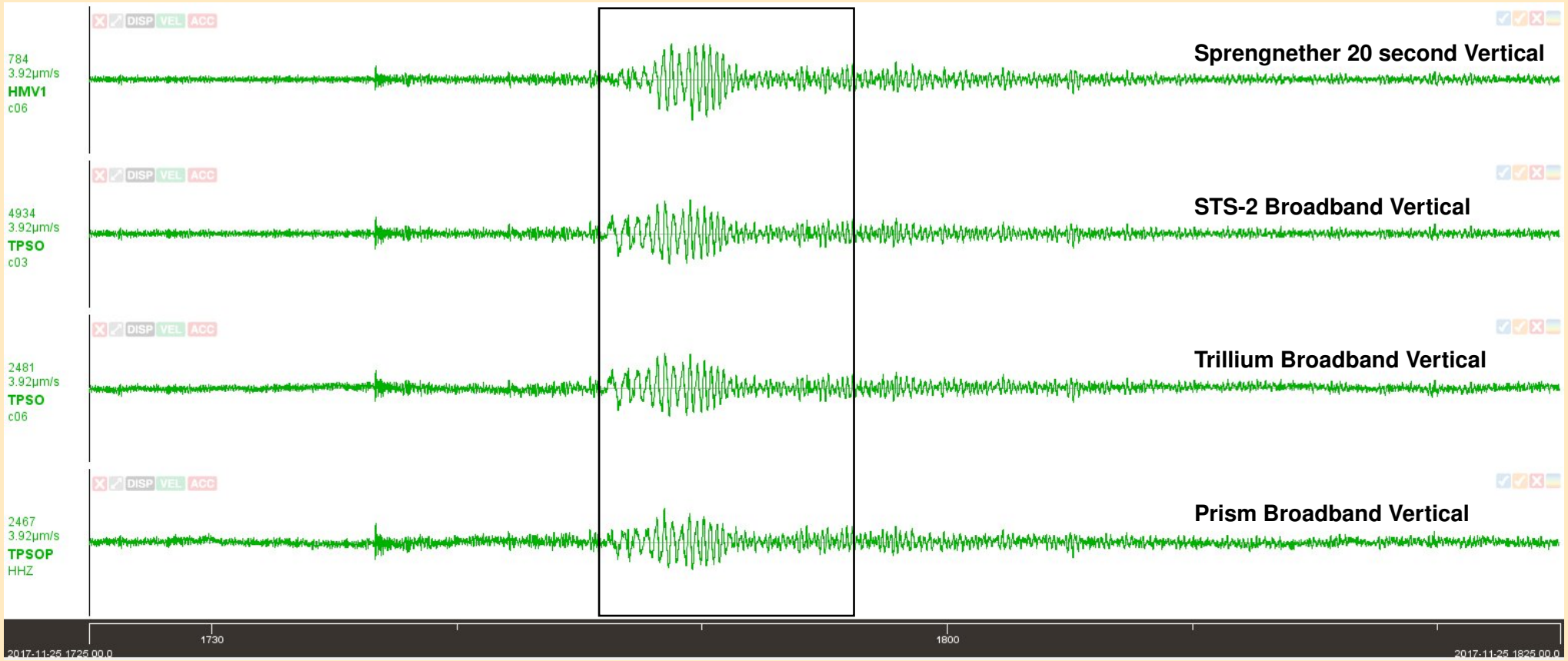


Figure 1 - One hour commencing 2017-11-25 17:25:00. New Caledonia M5.8 quake of 2017-11-25 17:30:01. P wave arriving at 17:36:40. Image created using "Waves" software from SRC.

The boxed area in Figure 1 above is designating 10 mins. of time commencing 17:46:00 and is enlarged in Figure 2 on the next page. In both images, right at the very beginning of the trace and for the last half of the trace, it is visually apparent that there is close agreement between all four seismometers.

Lagging behind of the three modern force feed-back seismometers. However the time where the long period Love and Rayleigh surface waves occurred, had vertical ground motion periods ranging from some 30 seconds to some 15 seconds. In this time of long period ground motions it is readily apparent that all three modern force feed-back Velocity sensing

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

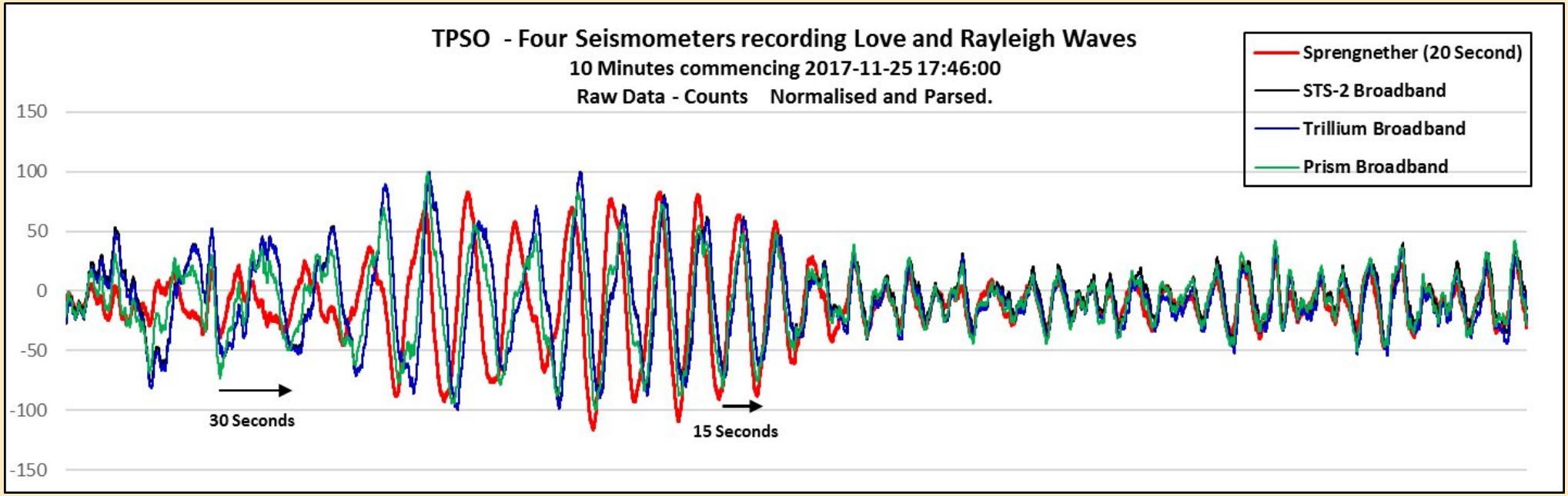


Figure 2 - 10 minutes commencing 17:46:00 showing four seismometers on the pier of TPSO recording Love and Rayleigh waves. (Raw Data – Counts, normalised and parsed).

seismometers lagged behind the RED Line of the Velocity sensing historic Sprengnether. The technical term for a seismometer's output lagging behind the ground motion (or in this case, lagging behind another seismometer on the same seismic pier) is Phase Response.

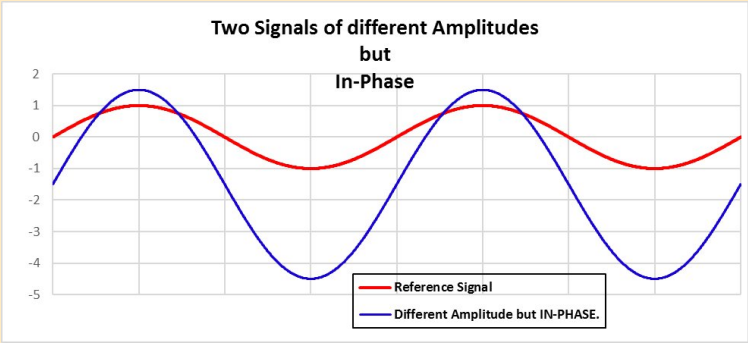
Phase Response.

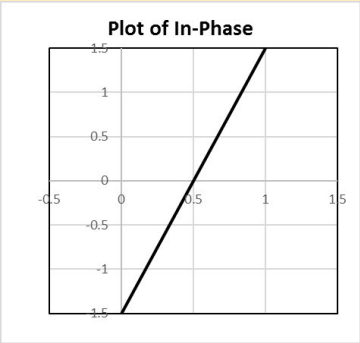
Put simply, Phase Response is by just how much does one oscillating signal lag behind another signal. (Measured in rad or measured in degrees)

In-Phase.

On the next page, the two images illustrate a reference signal (RED) and another signal (BLUE) which are in-phase. Notice they are not of the same amplitude, simply in-phase. But by using a very simple method we can show that these two signals are in-phase. Simply plot the data of one signal on the X-axis, and simply plot the data of the other signal on the Y-axis. If the two signals are in-phase, then the resulting Phase Response Plot is always a straight line lying up to the right.

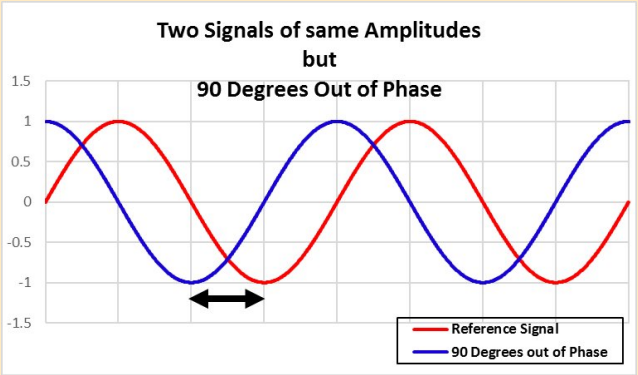
So, is SAA's 55 year old historic Sprengnether Vertical really up to the challenge?

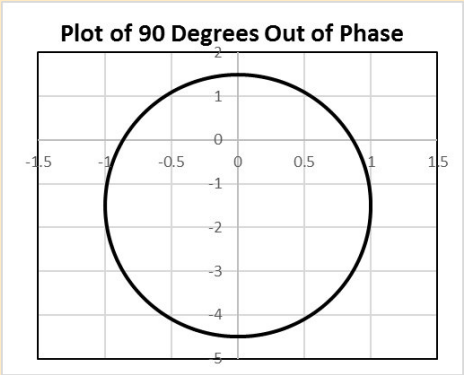




90 degrees Out of Phase.

Again, we can show if two signals are 90 degrees out of phase, by using the very simple method of plotting the data of one signal on the X-axis, and simply plot the data of the other signal on the Y-axis. If the resultant Phase Response Plot is a circle, then the two signals are 90 degrees out of phase.





Other Phase Delays using this simple method.

It can also be shown if two signals are 45 degrees out of phase then a Phase Response Plot having an ellipse will be produced and signals 180 degrees out of phase will produce a Phase Response Plot of a straight line going up to the left.

The extreme sensitivity of this simple Phase Response Plot method in showing phase response between two seismometers on the same pier, it is easily demonstrated by deliberately shifting the timing of one data set against the other data set, by just a few 1/100th of a second. Resulting in a noticeable change in the generated Phase Response Plot.

Phase Response Plots when comparing the STS-2 against the historic Sprengnether, the Trillium and the Prism seismometers.

Using the Normalised and Parsed Vertical Raw Data from the four Velocity recording seismometers for the 10 minute period as shown in Figure No. 2.

Data from the STS-2 seismometer was compared in turn with data from the historic Sprengnether, the Trillium and the Prism, to produce the following three Phase Response Plots, between four seismometers all on the same pier.

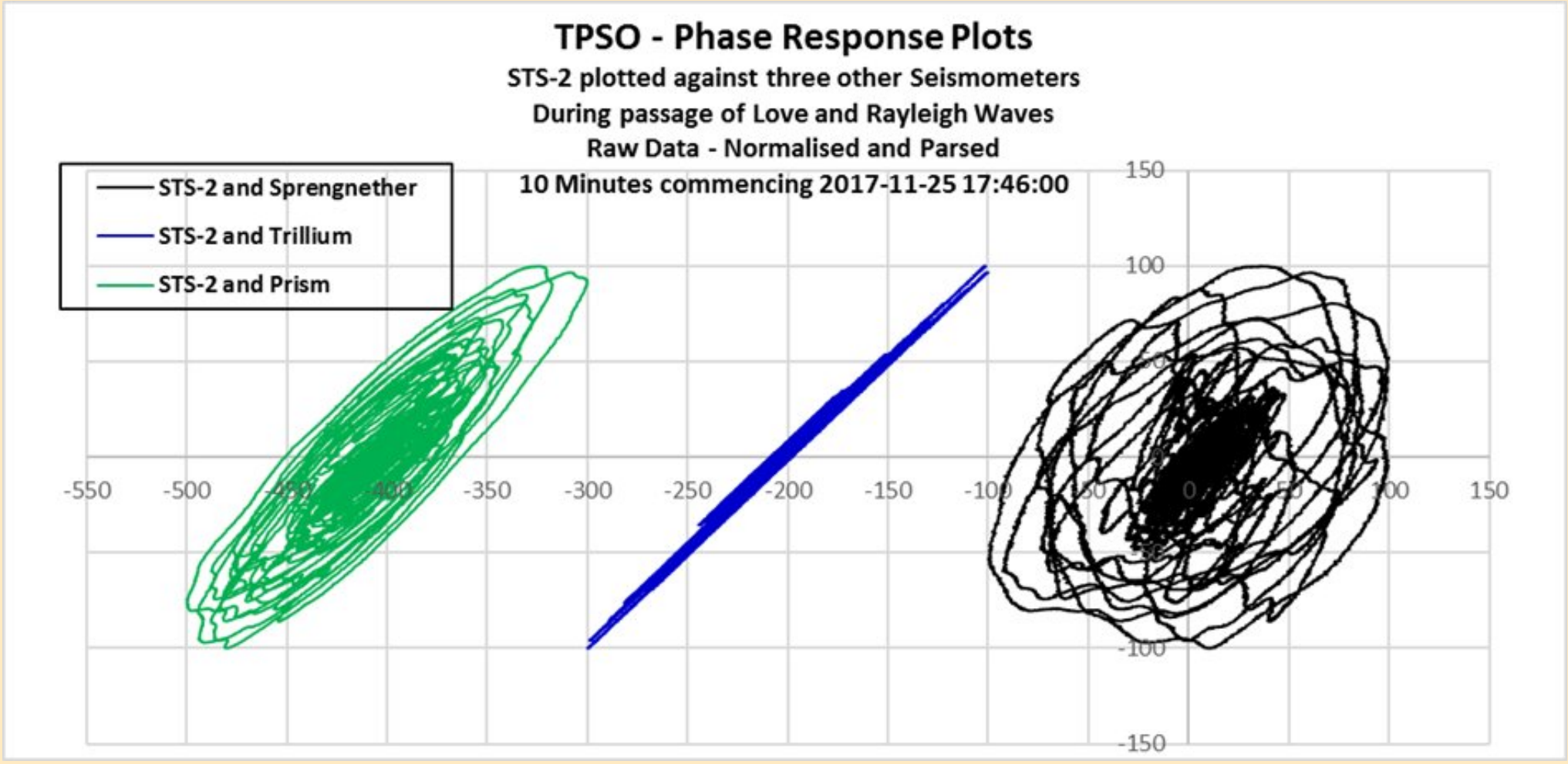
The three Phase Response Plots show:

a) Historic Sprengnether

The circular pattern of the BLACK Phase Response Plot above, shows the historical Sprengnether and the STS-2 to have been at times almost 90 degrees out of phase one with the other.

Figure No. 2 shows this out of phase, occurred during the first part of the 10 minute period when the 30 second to 15 second period surface waves passed thru and shows that the STS-2 response to ground motions lagged behind the Sprengnether's response (Red trace) to ground motions by some 90 degrees.

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



Phase Response Plots between the STS-2 and (a) the historic Sprengnether, (b) Trillium and (c) Prism seismometers. All being on the seismic pier of TPSO during passage of the Love and Rayleigh waves in Figure No. 2. Vertical component.

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

For the last part of the 10 minute period, the denser "central core" of the BLACK Phase Response Plot, shows the Sprengnether and the STS-2 being much closer to each other in phase, during the period when ground motions were generally less than 10 Seconds in period.

b) Trillium.

The almost straight line of the BLUE Phase Response Plot shows the STS-2 and the Trillium to have had an almost identical response to the ground motions and as such being very much in phase one with the other. That is, almost identical data.

However, as can be seen in Figure No. 1, the Trillium trace displays a slight "wobble" around the centre line. A "wobble" having a period of some approximately one minute. This "wobble" alternatively puts the Trillium data slightly above and then slightly below the centre line. This difference between the "steady" STS-2 trace, and the Trillium trace with a slight "wobble" then, is the cause for the slight "thickening" of the otherwise straight line BLUE Phase Response Plot.

And as regarding the almost thin straight line Phase Plot indicating an almost identical Phase Response to ground motions by the STS-2 and the Trillium. One need not look any further that the fact that historically, certain well known seismometer instrument designers were involved in the design of the Streckeisen STS-2 in 1990, and then in the design of the Nanometrics Trillium in 2004.

c) Prism.

The pronounced elliptical shaped GREEN Phase Response Plot comparing the Prism with the STS-2, shows that there was slightly less than 45 degrees phase difference between these two instruments during the period of the passage of the surface waves. That is, as Figure No. 2 shows, the Prism is shown to have responded to long period vertical ground motions with a phase delay being almost 45 degrees shorter than the phase response of the STS-2. And being just more than 45 degrees phase delay as compared to the Sprengnether.

This is the best result of any of the three force feed-back seismometers, and reflects the pendulous design of the Prism, including Beryllium/copper hinges and the use of a Michaelson interferometer [same technology used in LIGO], rather than a capacitive type, and the use of lightweight "proof mass".

The Score.

Compared to the historic Sprengnether long period Vertical the Prism is shown to have had a phase delay of just more than 45 degrees, whilst both the STS-2 and the Trillium both had a phase delay of almost 90 degrees. During the period of long period vertical ground motions.

For the critics.

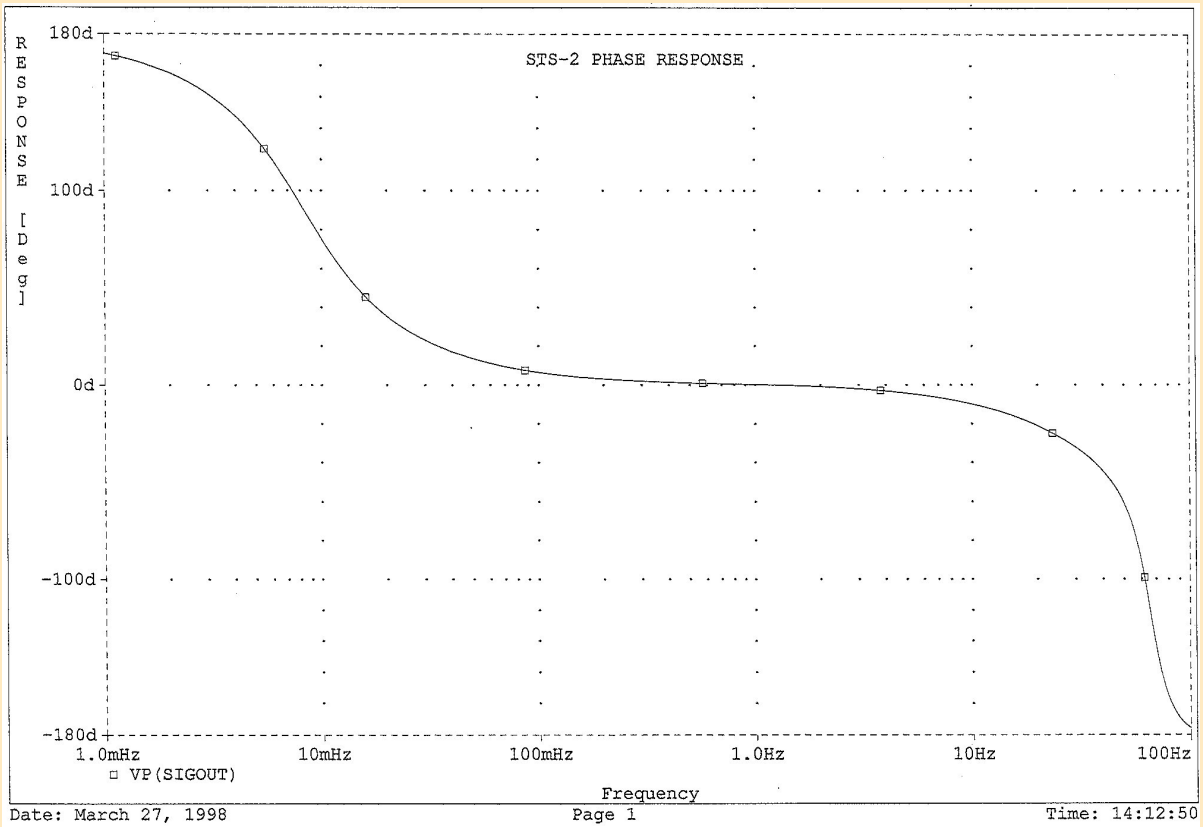
Just in case you think a simple old-fashioned "coil/magnet" seismograph, cannot outperform a complex modern force feed-back seismometer, in regard to phase response during long period ground motions, then,

a) The four traces shown in Figure No. 2, clearly show the historic Sprengnether reacting to 30 second to 15 second period vertical ground motions BEFORE either the Prism, and reacting WELL BEFORE both the STS-2 and Trillium, and

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

b) The "Phase Response" of Nanometrics Trillium T120PH S/N. 1021, being tested on the pier of the Sandia National Laboratory located near to Albuquerque, New Mexico USA, was stated to be 74.99 degrees at 100 second (10mHz) ground motion, and

c) The following graph is from the STS-2 Manual, Page 20. "Phase Response". Showing for example, that for a 100 second period ground motion (10mHz) the STS-2 would have a 75 degree Phase Response.



"Phase Response" of STS-2 Degrees vs Frequency.

That is, both the STS-2 and the Trillium, both state an identical Phase Response of some 75 degrees when measuring ground motions of 100 second period.

Which goes to show, a simple "passive" historic seismometer set up specifically to respond to 20 second period surface waves does not have the phase delay to surface wave ground motions that modern force feed-back seismometers have.
These phase delays to ground motion could be called a type of "frequency-modulation", giving rise to spurious spectral features found in PSD's of broad band force feed-back seismometers, having nothing to do with real earth motions.

In the next Newsletter we will discuss both:
• the theoretical response of the simple historical Sprengnether with respect to ground motions of various periods, and
• why ground motion VELOCITY is always 90 degrees out of phase with ground motion DISPLACEMENT and why displacement seismometers have certain distinct advantages over Velocity seismometers.

Paul Hutchinson - 19 March 2018

[1] Sprengnether Long Period Vertical S/N. 2168.
[2] STS-2 S/N. 99712
[3] Trillium TC 120 S/N. 003173. On loan to TPSO from David Miller
[4] Prism TPSO hosting SRC's optical interferometer
[5] Galperin Bruce Townsend "Symmetric Triaxial Seismometers"

Member Sites

EPSO: Coonabarabran, New South Wales
Location: 31.27S, 149.22E
Owner/Operator: Michael Andre Phillips

Blessed Vault

As many of you know, I operate a small seismic observatory located at Coonabarabran, NSW, and the key feature of this facility is that it is located underground within a recycled 5000-litre steel water tank. I have named this vault the Edward Pigot Seismic Observatory (EPSO) in honour of Pigot's extraordinary contribution to Australian seismology, along with various other fields of science. Since Pigot was a Catholic priest of the Society of Jesus (i.e. Jesuit order), which is also historically associated with seismology and geoscience, I thought it would be fitting that our local Catholic Church was aware of the EPSO vault and the connection with Pigot. I had also noticed that our town's Catholic Church presbytery building has the letters 'AMDG' conspicuously carved into it, which is a reference to the latin motto of the Jesuits. So it would appear that the Jesuits had a presence in Coonabarabran at one time, and probably had a hand in building the original church and school. All of this may seem peculiar coming from me, a no-nonsense atheist, but I do have an interest in history and symbolism, and so I put Pigot's story and EPSO's existence to our town's resident Catholic Priest, Fr. Jaboneta Reynold.
I preambled our discussion with an admission that I wasn't a member of his faith, or any faith, but asked if he would consider undertaking a formal Catholic blessing of the EPSO vault, and he said he would be pleased to.

Fr. Reynold in EPSO vault with Fr. Pigot looking on

And so it was, that a week or two later Fr. Reynolds arrived at the EPSO vault and descended down into it, with bottle of holy water at hand. Catholic blessing ceremonies follow a standard text that takes only a couple of minutes for a priest to read, and during the reading we both enjoyed the solemnity of the event and peculiarity of the location. As for holy water, he thoughtfully avoided sprinkling it on the ample bare electronics within the vault. As we returned to the surface, Fr. Reynolds commented, "…well… I've blessed a few weird things in my time, but never a hole in the ground!". In fact Fr. Reynold is rather a good-humoured joker who has many interesting and funny stories of his life as a priest, and I expect he'll add the EPSO vault blessing to his repertoire of funny yarns. I had been worried he might have thought I was taking the mickey* of him but fortunately he took me seriously, and with good humour (*pardon me). And who knows, perhaps out there in his celestial geophysical observatory Fr. Edward Pigot is getting the last laugh and is pleased to see that his memory lives on.

Michael has indicated that he will submit an additional "technical" article on the Edward Piggot Seismic Observatory in the near future.