Direct Burial Posthole Sites in Yukon Yield Excellent Results

The Trillium 120 Posthole broadband seismometer was the sensor of choice for all 7 sites.

A new broadband seismograph network for passive seismic imaging of earth structures has been installed in the Yukon using a new Posthole installation method that is now yielding excellent results. The University of Ottawa turned to Nanometrics for a turnkey real-time seismic network consisting of seven Libra II stations as part of a five-year study to better understand seismicity and crustal behaviour in the Mackenzie Mountains and River Basin region of the Yukon. This area is known to be the most seismically active in Canada. Pascal Audet, Assistant Professor, Faculty of Science, Department of Earth Sciences, University of Ottawa, will use the seismic data to determine earthquake patterns and map faults in Canada's northwest. He explains that, "*despite being one of the most seismically active regions in Canada, this area remains very poorly studied due to a lack of seismic station coverage. This new network bridges that gap and allows us to determine the location and magnitude of small earthquakes very accurately and estimate seismic hazard in this area*."

Network Design

Site selection and budget were key considerations when designing and installing this seismograph network, which was challenging given the extreme northern climate with brutally cold winters. Despite the low power of the Libra II VSAT system (~5 Watts), it was decided to use mains power for 5 stations due to low solar insolation in the region and the uncertainty associated with snow depth and overall accumulation. The remaining 2 stations would be solar powered. The five stations were connected to AC power on municipal property and using Trillium 120 Posthole seismometers mitigated the anticipated cultural noise from these sites. The 2 remaining solar powered sites were placed in very remote locations near airfields for better access.

The Trillium 120 Posthole broadband seismometer was the sensor of choice for all 7 sites because it is ideally suited to provide quality data with minimal site preparation. It has been demonstrated with other Trillium 120 Posthole

Using the new hand dug technique to install the Trillium 120 Posthole enabled the Nanometrics field engineering crew to effectively deploy high quality seismic stations in remote locations earlier than scheduled.

installations that it is possible to reduce site noise below that of the instrument and at the same time keep assets secure with a minimized station footprint.[1] Furthermore, a near surface burial in sub-arctic and temperate regions also easily eliminates tilt noise induced through the freeze/thaw cycles. When installed on competent material the sensor performance is excellent as there are inherent noise field benefits associated with installing a seismometer in a down-hole environment that are not available to vault instruments. Cultural noise is reduced and horizontal noise, in particular at longer periods, is significantly suppressed in down-hole environments. While this is somewhat depth and lithology dependent, as this deployment has shown, excellent results are possible even with simple near-surface direct burial installations.

Methodology

Q: *How deep should the sensor be?*

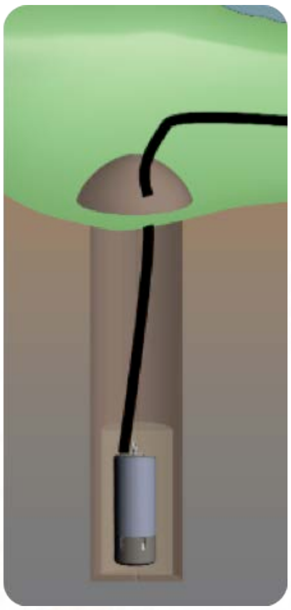
A: *"As shallow as possible, as deep as necessary,"*
Neil Spriggs, Co-CEO, Nanometrics

The Nanometrics field engineering crew used a new hand dug direct burial Posthole installation method to install the seven Trillium 120 Postholes in the above-mentioned remote locations. By using the earth as a natural vault, this method reduces the time and cost usually incurred when building a surface vault which requires labour intensive infrastructure. There are distinct advantages in directly burying the sensor because it is insulated and when installed in competent material, it is more closely coupled to the ground. In our experience, this method always yields better results than a surface vault at the same location, as the posthole sensor is more stable.

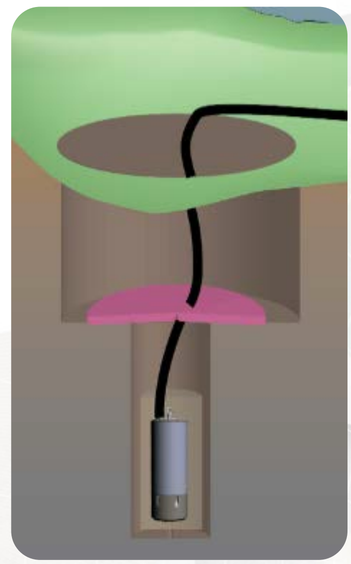
Before the sensor could be installed, a 10' area was cleared, which included removing trees using only a handsaw in heavily wooded areas. A 2' square area was initially hand dug with a shovel to allow space for the auger. From that initial hand dug depth, and depending on the geology, the hole was deepened using an auger with a 3' bit and 2' extension. The sensor was placed in the hole that was up to 6' deep and the field engineer was able to use his hands to orient the sensor to north and then settle the sensor so it was

[1] *"Comparison Study between Vault Seismometers and a New Posthole Seismometer,"* Poster Paper, Seismological Society of America, presented in Salt Lake City Utah, 2013.

in a stable position. Sand was placed in the bottom 6", the sensor was surrounded by sand and then another 6" of sand was placed on top. The native soil was added to the remainder of the hole and a 4" insulating cover was used to seal it. The 4" of insulation is equivalent to 4' of soil, which in theory should help get below the seasonal frost and mitigate the potential noise effects from the frost. (Seasonal frost typically reaches down 3' to 4'.)



Above:
Alternative direct burial technique used by PIC for the Posthole sensors deployed at Poker Flats, Alaska (see SQLX PDF plots below). One inch of sand was used at the bottom to ensure the sensor settled properly and the sensor was then covered in sand. Native soil was used to fill the remainder of the hole with clay at the very top to cap it off.



Hand dug hole with partially buried seismometer. Note the seismometer was placed in a narrower hole at the bottom of the trench, and has had sand poured around it to stabilize it. Afterwards the native soil was replaced in the trench, filling it up to the original surface level and covering the seismometer to a depth of 2 feet (60 cm).

The installation was completed one week ahead of University of Ottawa's scheduled deadline, and took 16 days, despite the fact that inter-station distances were significant. *"I drove a total of >4500 km on sometimes very difficult dirt roads in that trip,"* explained Pascal Audet.

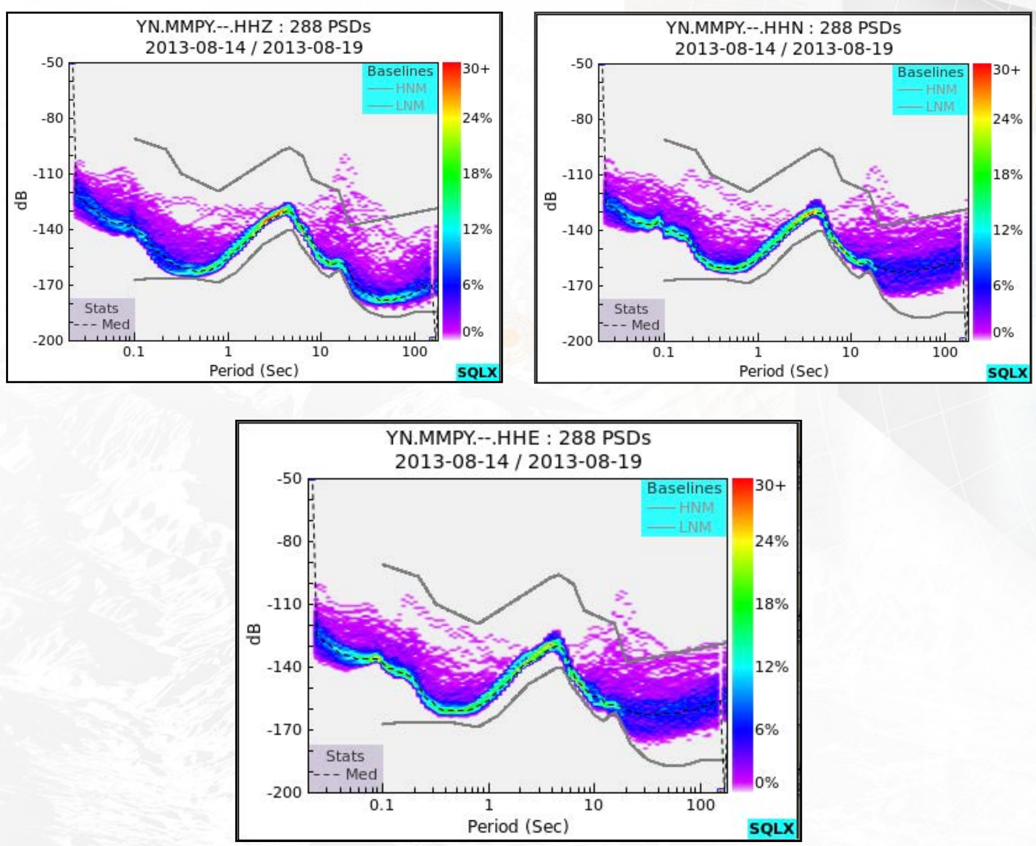
Results

Now that the stations are fully operational, the much-anticipated real-time data from these hand dug direct burial postholes are yielding excellent results. The results are even more exemplary, given that 5 of the 7 stations were placed in culturally noisy areas because the stations are connected to municipal AC power sources.

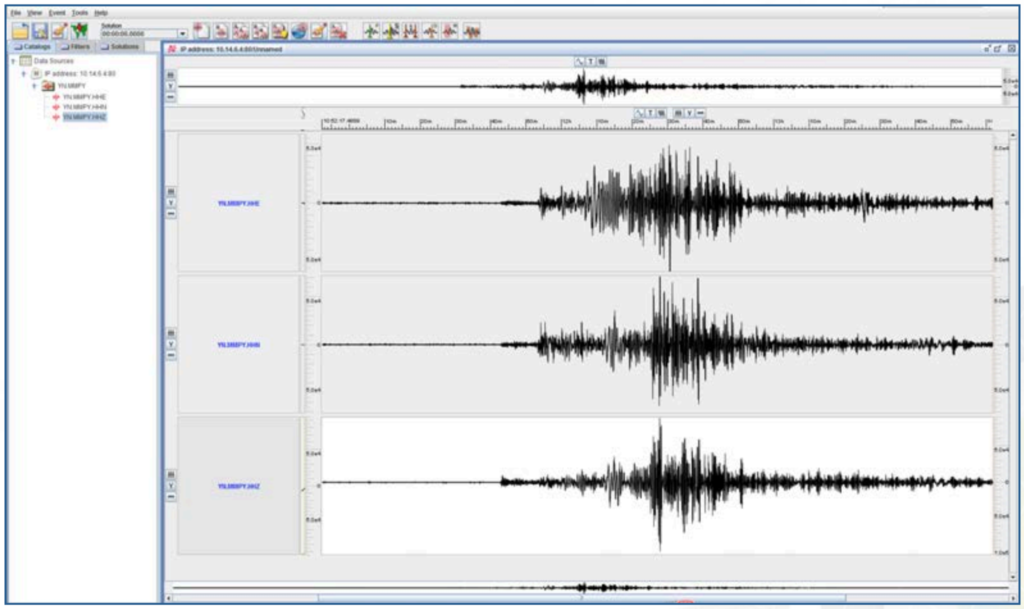
"Nanometrics essentially provided a highly customized turnkey product where each step of the process was handled professionally and in constant communication with our team."

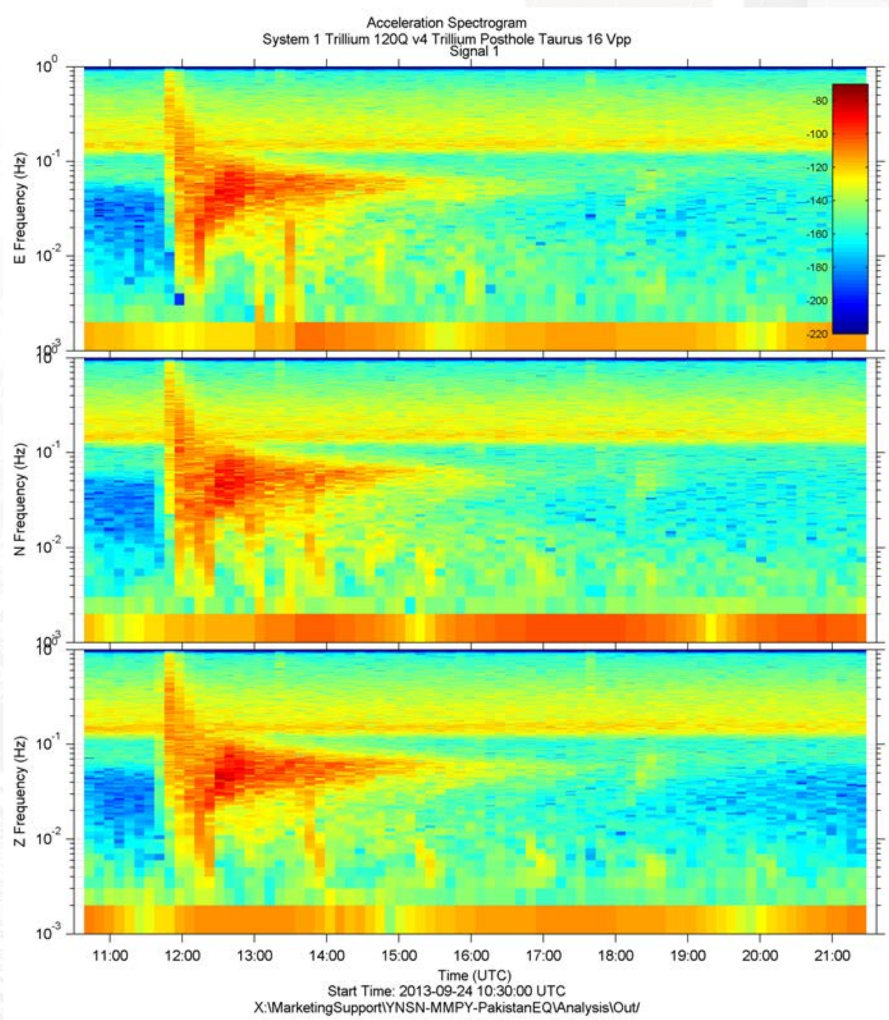
- Pascal Audet

Data from the University of Ottawa station, YN.MMPY, as shown in the SQLX PDF plots below:



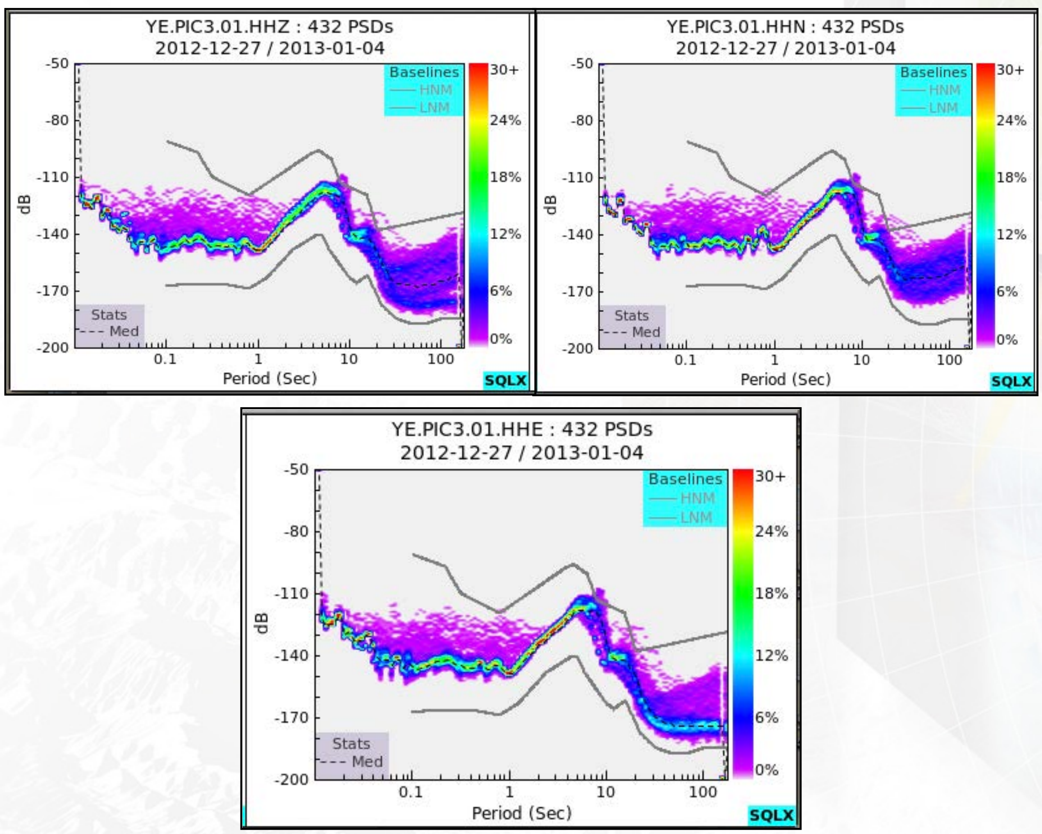
YN.MMPY, University of Ottawa Mackenzie Mountain Station, Yukon, Canada.





Pakistan Earthquake recorded on 2013-9-24 at *YN.MMPY, University of Ottawa Mackenzie Mountain Station, Yukon, Canada.*

These outstanding results are also being evidenced in direct burial postholes in other networks around the world. For example, in YE.PIC3, Passcal Instrumentation Center station at Poker Flat, Alaska, USA, the SQLX PDF plots demonstrates that this Trillium 120 Posthole sensor approaches the NLNM on quiet days; a level of horizontal performance typically achieved only in deep boreholes. It is also worth noting in the data plots for both stations how the Z channel is close to the NLNM, with the horizontal performance better than a typical surface vault. These plots demonstrate world-class performance from a very simple and low cost installation technique.



YE.PIC3, Passcal Instrumentation Center station, Poker Flat, Alaska, USA.

The stations in this real-time network transmit data to the GeoScience BC hub in Sidney, British Columbia and then to University of Ottawa. This network will complement the CNSN (Canadian National Seismograph Network) and these 7 new stations will help to strengthen the CNSN by adding station density and filling a gap in the station data. Audet will visit the stations once a year for the remainder of the study.

"Doing fieldwork in the Canadian northwest can be logistically very difficult, and variable field conditions require a robust and versatile product. To remain on budget, this operation also required minimizing time spent in the field without compromising on the quality of the installations. The direct burial of posthole instruments was certainly the best solution in terms of saving time in the field and delivering extremely high-quality data."

- Pascal Audet, University of Ottawa

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