# Going outside, acquisition and learning in the field

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## ABSTRACT

CREWES continues to perform seismic acquisition in the field using industry equipment. This opens up the possibility of taking ideas from the minds of students and staff and bringing them outside to try in real world situations. Students, staff and sponsors are able to see our equipment and suggest new methods in using it. CREWES data sets are often created using this equipment. CREWES also brings some of this equipment and several support staff to the annual geophysics undergraduate field school. The Geophysics program at the University of Calgary is one of the very few that has access to commercial grade seismic equipment and has the opportunity for students to use it. For many students this is the first time that they actually observe and participate in the acquisition of seismic data. This provides a much better understanding for these future geophysicists of how the environment affects data. This year CREWES assisted with a survey at the Brooks CMC test site, did a small demonstration at Earth Science for Society and aided with the annual geophysics field school.

## INTRODUCTION

CREWES performs research with industry standard equipment every year. This equipment has been used for many experiments as well as the creation of several data sets. There is property owned by the University of Calgary where several experiments have been carried out. This has also been the location of a field school a few years ago. Two years ago it had two test holes installed for downhole recording (Hall et. al., 2013). This year, however, that field was not used for any experiments.

A demonstration of some of the tools used in geophysical acquisition were demonstrated as Earth Science for Society. This is an event that schools bring students for a field trip. It took place over a few days in March.

The first acquisition project of the year was a test out at the Brooks Field Research Station. During the week of May 18th CREWES supported other research groups by providing a source for a new downhole recording system.

The Geophysics 549 field school took place September 21st to August 2nd. CREWES sent several staff to teach the students and maintain the equipment.

## EQUIPMENT

For many years CREWES has had access to several acquisition and testing systems that are industry standard for research. This allows for new ideas on seismic methods to be tested from start to finish.

The largest system that has been used the most is an Aram Aries system. This can be seen in Figure 1. Aram is now Inova, and although the system is no longer being updated it is still used worldwide by many acquisition companies and it is still supported. This system can be used with single component and three component analogue geophones. The Aries is a cabled system requiring that all the receiver components be wired into a recording computer. This computer is kept in a box on the back of a Ford 450 truck. This computer is also connected to a VibPro which is used to control a vibrator source. The VibPro can also be configured to be used with an impulse source such as dynamite. Also connected to the recording computer is a Verif-i GPS synchronizer. This device uses GPS satellites to calculate the current global time. When the VibPro is triggered this device outputs the current time via a serial connection to the recording computer which records this time in the acquisition notes. The Verif-i has become an important piece of equipment as it has been found that running several different recording systems during a single survey creates many different file creation times that do not match up.

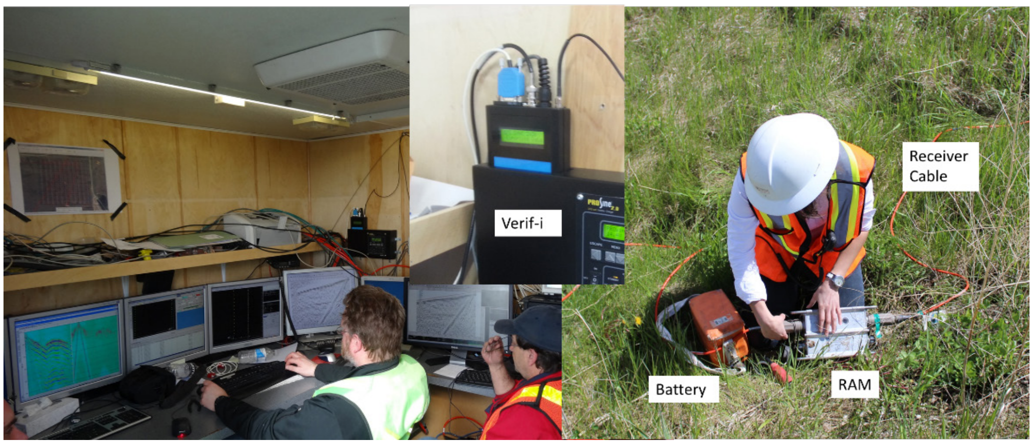


FIG. 1. The Aries recording system. The inside of the recorder can be seen on the left. On the right some of the equipment on the ground and the Verif-I can be seen in the middle.

Outside the recorder are the other components to this system. These consist of Remote Acquisition Modules (RAMs), Line Taps, geophones and cables. The RAMs are eight channel twenty four bit analogue to digital converters with on board memory and self-testing capabilities. Typically these are connected to other RAMs on the spread via a cable. These cables have eight take outs between the RAMs that connect to geophones (four are connect to one RAM and four to the next). A 2D survey consists just one of these lines where as a 3D consists of two or more.

In order to bring the data back to the truck the receiver line must be “tapped”. This is what the Line Tap is built for. The Line Tap is connected to the receiver lines as well as a base line cable. The baseline cable differs from the receiver line in that it has no take outs for geophones. In short: analog data is sent from the geophones to the RAMs where it is digitized and then sent to the Line Tap which sends it to the recorder. It has proven to be a very reliable system. The Taps and RAMs require power and run off of batteries. Two Ford 350 trucks are used to carry the RAMs, Taps, cables and batteries to the field.

Although the Aries system is solid and reliable, it is somewhat limited by its portability. For smaller surveys that require either a higher resolution in receiver spacing or the ability to be used in more remote locations there is a Geometrics Geode system. This is another cabled system, but is configured differently. Where the Aries only requires one cable between RAMs this system requires a data cable between Geodes and a separate receiver cable. The receiver cable has twenty four take outs for geophones per Geode. The data cables are simply a ruggedized Ethernet cable. A Network Interface Box (NIB) is used to connect the Geodes to a laptop. New for this year a Panasonic Toughbook, seen in Figure 2, was purchased to be used with this system. The old one was starting to lose keys off of the keyboard and was running an out of date operating system.


FIG. 2. The new laptop to use with the Geode recording system.

For vertical seismic surveys there are a few options. There are geophones permanently installed in a test hole at the location just outside of Calgary. These are currently wired to be used with some custom adapters (built by Malcolm Bertram) to connect to the Aries system. There is also access to a fibre optic US Seismic System Inc. (USSI) three axis down hole geophone system. Figure 3 shows this being installed into the test hole at the Priddis test site. This needs to be winched down a well and then uses nitrogen powered clamps to secure itself in place.

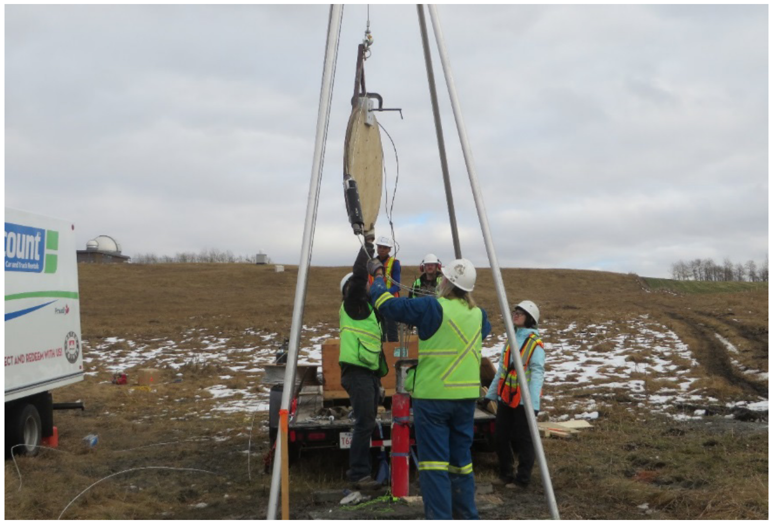

FIG. 3. The USSI fibre optic down hole system being installed down a hole.

New this year is an Inova Hawk recording system. This system differs from anything CREWES had access to before in that it is a nodal system, meaning that it does not require any cabling to connect the receivers to a recording computer. Instead the Hawks are programmed with acquisition parameters before being taken to the field. Hand held computers are also programmed with these parameters. The Hawks are then taken to a previously surveyed point and connected to a geophone, Figure 4. Unlike the Aries or Geode system the Hawk can use either analog or digital geophones. The system CREWES has access to is currently set up to use three component geophones. The Hawk is then connected to a battery and boots up. Once it is up and running a hand held computer is used to wirelessly connect to the Hawk and tell it which point on the survey it is at. Once that is done the unit will stay there and record according to the job parameters until the job is finished or the battery is drained. Once the job is done the Hawks are brought back from the field and loaded into a rack which downloads all the data. This is shown in Figure 5. A source computer is used to keep track of when and where the source(s) was/were set off and that information is used after the data is downloaded to correlate and pick zero times.

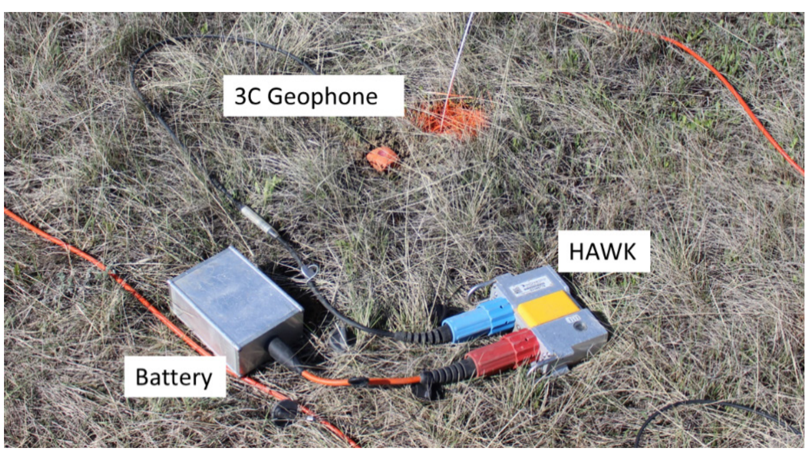


FIG. 4. The Hawk nodal system deployed in the field.

FIG. 5. The Hawk recording devices in the download rack.

As the ability to generate earthquakes on demand has not yet been developed, the use of various controlled seismic sources is employed. The most famous one is the Industrial Vehicles International Envirovibe seen in Figure 6. This is a small, low impact vibrator source built into a tractor type vehicle. Since it is low impact it allows CREWES to perform surveys in areas that are too sensitive for full size vibrators. It is transported to field locations on a trailer pulled by a Ford 550. The system used for control of the vibe is a Pelton VibPro. As mentioned above there is one in the recorder. The VibPro is used to load sweep parameters via radio to sync the source with the recording system.


FIG. 6. CREWES' favourite source, the IVI Envirovibe.

Buried dynamite is also used for some surveys. Typically a ShotPro II is used to set the dynamite off. Since the ShotPro II and the VibPro use the same language, the VibPro can be used in the recorder for dynamite sources.

Recently the old hydraulically driven elastic weight drop trailer was retired. The new thumper which can be used vertically and at forty five degree tilts is now the only thumper CREWES has access to. The two sources are display side by side in Figure 7. This thumper was built by Malcolm Bertram and Eric Gallant and uses a nitrogen spring. Hydraulics are used to lift the hammer against this spring and when it reaches the top it is released, hitting an aluminum foot which sends the impulse energy into the ground. This thumper has been successfully used with a wireless trigger box and a Geometrics style trigger for seismic surveys.

FIG. 7. The recently retired P-wave thumper on the left and the replacement P/S-wave thumper on the right.

And of course there is the seismic standard of hitting a plate with a sledge hammer. This is typically done with the Geode system as it is usually used for refraction surveys. A Geometrics style trigger is attached to the hammer using tape and provides a closure when the hammer impacts the plate.

CREWES also gets a lot of use out of a differential GPS system displayed in Figure 8. This system uses two GPS receivers to achieve accuracy not possible with just a single receiver. The two receivers are referred to as the base station and the rover. The base station is set up at a “known” location. Ideally this location is an official survey monument, but can actually be any location. If a survey monument isn’t used the base station can be set up to take an average of one reading per second for a user selected amount of time. The longer the average, the more accurate the location will be. Once the base station is set up it begins to calculate the difference between its known location and the location it is receiving from the GPS satellites. It then broadcasts these correction over a radio. The rover receives this transmitted correction and applies it to its GPS received location. With this setup the accuracy is within tens of centimetres.


FIG. 8. The two main parts of the differential GPS system, the base station and the rover.

CREWES has half ownership of a Pulse Ekko Pro ground penetrating radar system. This system has the transmitter and receiver as two separate pieces. Both are connected to a control module. The transmitter and receiver are place on the ground at a set separation distance and the control module is then used to take a reading. The transmitter and receiver are then moved while maintaining the same separation and then another reading is taken. Repeating this process creates and image of the near surface using radar.

## SAFETY AND FIELD READINESS

It seems that safety is becoming more and more prevalent in today's society. As such all field work must be done with safety being the number one priority. To that end work does not start until everyone involved in acquisition has had a safety briefing where all known hazards are identified and solutions to each one discussed. A fairly recent briefing can be seen in Figure 9. A communications plan is created before any work starts. This plan will have contact information for nearby emergency services, where the job it taking place, where the people working will be staying and how often they will check in. For most trips it is simply a phone call, text, or email at the end of the work day stating that everyone has made it back to where they are staying for the night. In areas where there is no cell phone coverage there is a Spot GPS system. This unit is owned by the University of Calgary and uses satellites to transmit a message stating that everything is fine. When this signal isn't sent at the agreed interval emergency plans can be executed. The system also has an SOS button which will transmit the help signal as well as the GPS location.

Every person working in the field is required to wear the correct PPE. This includes hard hats, high visibility vests, steel toed boots and appropriate clothing. It is also required that everyone in the field be able to communicate with everyone else. For this hand held radios are used.

FIG. 9. No work starts until everyone involved has been briefed on the specific hazards and safety procedures have been discussed and understood.

To date, there has not been an incident anyone has been injured and required medical assistance.

## EARTH SCIENCE FOR SOCIETY

For the second year in a row CREWES participated in Earth Science for Society. This is an event held at the Calgary Stampede Grounds that is designed to introduce some of the aspects of geoscience to young students and the public. The CREWES booth can be seen in Figure 10.

This year one of the line trucks was loaded up with seismic gear and displayed at the CREWES booth. There was also a display computer showing a slide show that had some demonstrations of the equipment in action. The geode system was brought in with about fifty single component geophones installed into a long four by four piece of wood. This allowed people to trigger the geode system by hitting the wood at one end with a tool and almost instantly see how the energy travelled to from one end of the wood to the other and even back again.

Another interactive piece of equipment that was brought was a seismometer connected to an oscilloscope which in turn was connected to a monitor. This allowed people to see how seismometers are able to capture the vibrations of people walking around on the floor.

The equipment that people seemed to be most excited about were the GPR units that CREWES brought. These are Noggin GPR units where the entire system is contained within a cart. The GPR is automatically triggered when the wheels turn. This allows for real time images to be built on the screen as the carts are pushed. Since ESFS is on the second floor of the building there wasn't much to see below. However, expansion joints in the concrete and some rebar did show.


FIG. 10. A line truck, the Geode system with geophones in a 4 X 4 piece of lumber, a seismometer (between the orange cones), a computer displaying a slideshow and a couple of GPR carts all on display for the public at Earth Science for Society.

## BROOKS SURVEY

In May of 2015, CREWES staff and students assisted in a geophysical survey at Brooks Field Research Station (Hall et. al., 2015). This survey used the Aries system with single component geophones as well as the Hawks system. Only a few Hawks were used just to allow some of the staff to get some practice deploying them and to have a look at how the data compared to the Aries. Both the Aries and the Hawks were laid out in a Southwest to Northeast line. This line was centred about an observation well that was recently drilled. A second line of single component geophones being recorded by the Aries system was laid out parallel to the first one hundred metres to the northwest. On top of the surface spread there was also a three component ESG SuperCable belonging to the Microseismic Industry Consortium deployed in the observation well. An overhead view of how the gear was laid out can be seen in Figure 11.

The EnviroVibe was used as a source for this survey. The source points were located along the line centred on the well as well as a half circle of shots around the well 400 metres away. These source points were shot three times as the SuperCable need to be moved for different depths.

For this survey the Hawk computer was actually the one running the vibrator source. This was done to ensure that the Hawk GPS timing would line up perfectly so we could use the timestamps to download and correlate the data from the nodes. The Aries system was running in a mode that allowed it to start when the radio signal from the Hawk system triggered the vibe.

The final test performed during this trip was running m-sequence sweeps created by Joe Wong while the SuperCable was being removed from the well (Wong et. al., 2015).

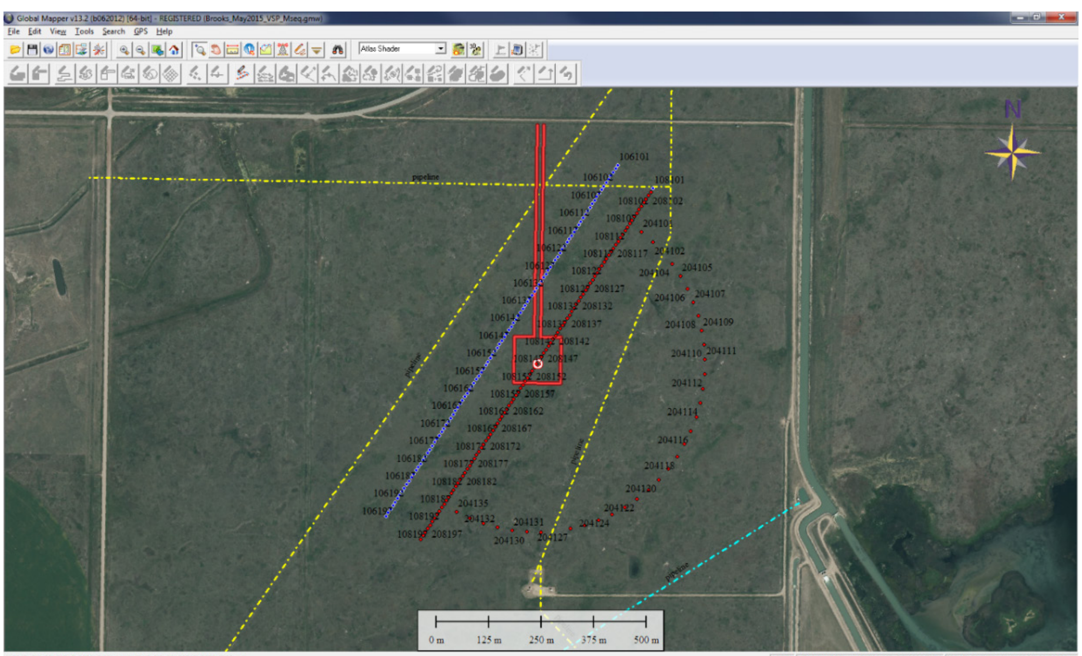


FIG. 11. The source and receivers around the well. The well is the white circle in the middle.

In preparation for this experiment it was required that the batteries for the Hawk nodal system be charged at Inova. At the time the Hawk system was so new that charging the batteries was not allowed as the proper fire extinguisher for lithium ion batteries had not yet been acquired. Thankfully Inova is located a short drive from the University of Calgary and allowed the use of their chargers and download racks. The proper fire extinguisher arrived after this acquisition survey as it was a special order item, Figure 12.

FIG. 12. The specific Class D fire extinguisher designed for lithium ion battery charging.

## FIELD SCHOOL

The University of Calgary has been running a geophysics field school for decades. The purpose of the field school is to introduce students to the acquisition of various forms of data, Figure 13. The students then spend some time analyzing these data and present a report to their professors in the evening. After the acquisition is done students spend several tutorial sessions working with what they have learned in the field and present reports which are graded. An oral exam also takes place.

FIG. 13. Students ready to experience data acquisition. Smoke from forest fires in North America can be seen in the background.

Field school builds on a prerequisite course detailing acquisition methods. Using what they have learned in this class they apply these concepts to the acquisition.

This year the field school was held at and near the Castle Mountain Ski Resort. This is an area which field school has been before and has proven to be a worthwhile local for decent data. Unfortunately there were several forest fires in North America this year which reduced visibility and air quality for the first week.

Field school begins with a scouting trip to the area. CREWES staff were involved with this. Once a few locations are chosen the permitting process began. The permitting is done through Outsource Seismic. CREWES staff also prepare much of the equipment and loaded everything onto the trucks. CREWES staff also notifies Alberta One Call to have any buried utilities flagged or otherwise marked.

During the first day CREWES staff left early in the morning and began to lay out a single component Aries line. At this time some of the utility companies that were notified by Alberta One Call came out to discuss the locations of buried items. For the most part these companies were satisfied that there was no ground disturbance due to the fact that the source is an EnviroVibe. This year the line was located in the ditch of a road know by the locals as the Toney Road just South of Pincher Creek, Figure 14. The line started at the West and headed East. The students would spend the first day in orientation and then start their acquisition on the second day. By having the staff lay out some receivers before the students arrived meant that the first group to acquire data could start as early as possible.

Field School 2015, 2-D crooked-line. UTM zone 11, NAD83

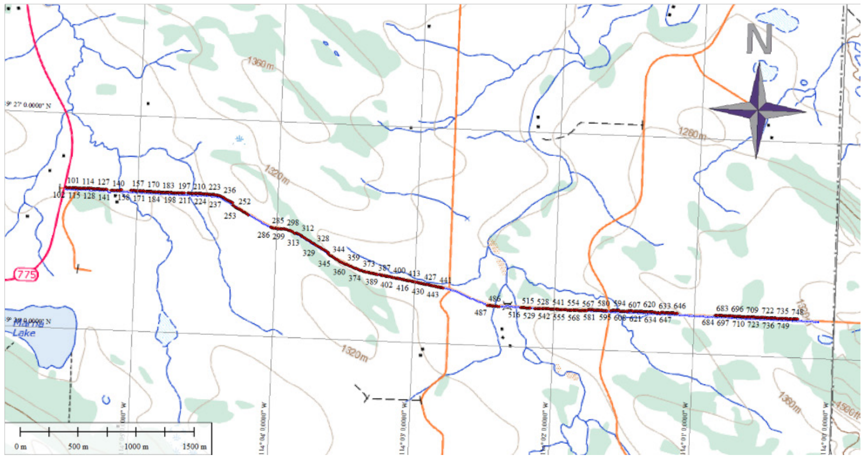

FIG. 14. The planned seismic line for the 2015 University of Calgary geophysics field school.

The date recorded in this area proved to be very interesting. By the end of field school the data quality was so good that the decision was made to return next year to continue this line.

While at the seismic reflection portion of the field school, which is the portion that CREWES is most involved in, the students were asked to run all the equipment and perform some data analysis. The geology of the area provided some very interesting points of discussions with the students. For example, it can be seen that there is dipping to the West on the local outcrops. This affected the first breaks on the data in that their velocities were different either side of the source. Students were also asked about frequencies, velocities and estimated depths to reflectors.

Each group of students spent two days on seismic reflection. The first day was spent working on the receiver line laying out and picking up gear. Once they had done that they spent some time doing chaining notes as well as surveying receiver and source points using the differential GPS, Figures 15 and 16.

FIG. 15. Students laying out cable and planting geophones for the seismic portion of the geophysics field school.

FIG. 16. Students learning how to use the differential GPS to survey the geophones that they laid out earlier in the day.

Looking as some of the raw data in Figure 17, the difference in the first breaks velocities due to the dipping geology is quite apparent.

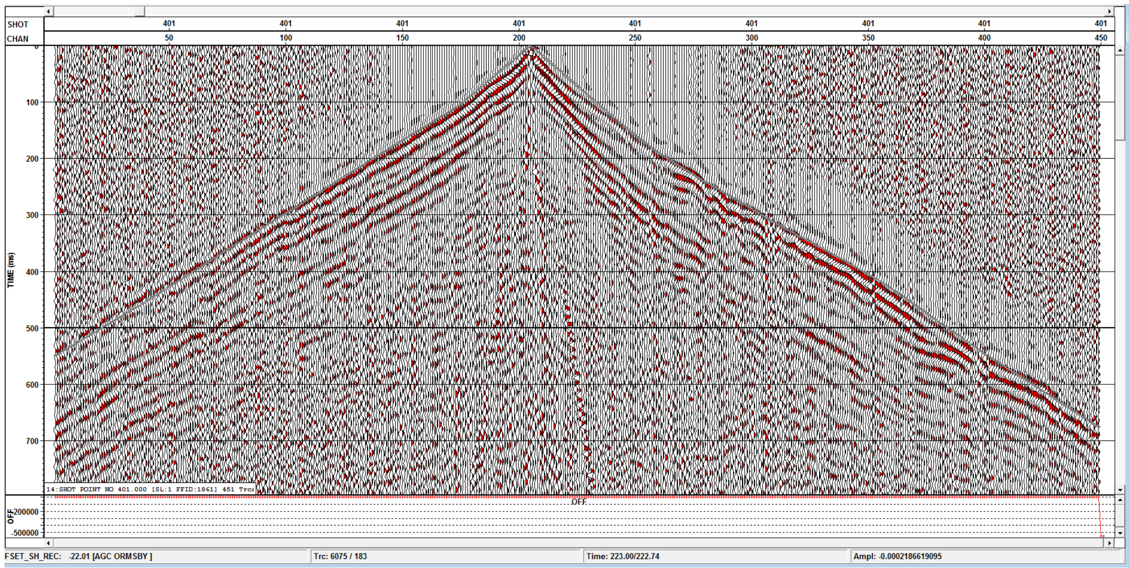


FIG. 17. The first breaks have different velocities on either side of the source caused by the dipping geology.

The geology of the area can be seen on the raw data records. An example is shown in Figure 18. Here the dipping layer actually breaks the surface of the earth and its effect on the data is quite obvious. There are also lots of reflections that can be see below the surface. Doing a simple analysis on some of these shows that the dominant frequency is about thirty Hertz. This spectrum is shown in Figure 19.

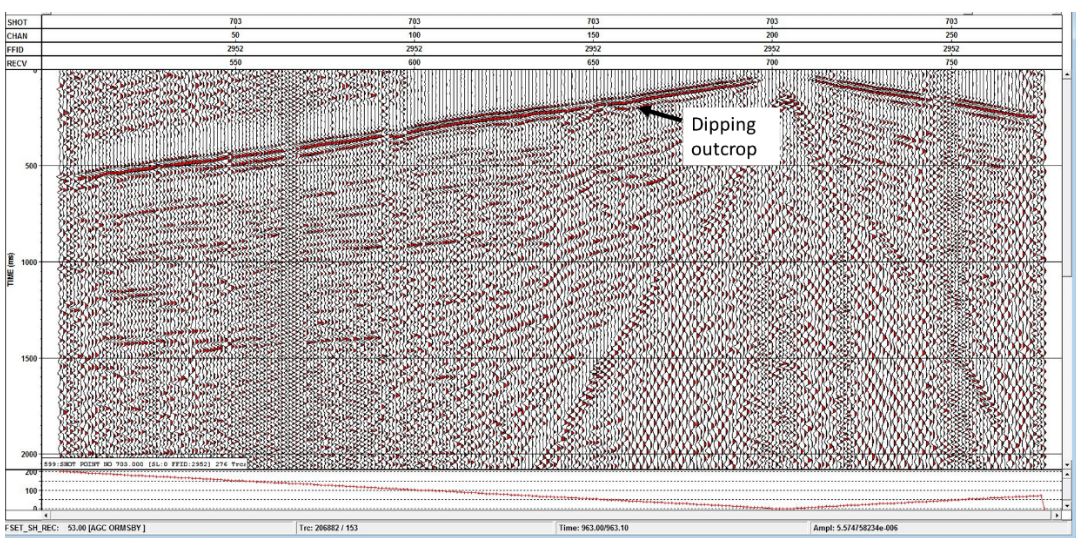


FIG. 18. An example of the data that the students were seeing immediately after a shot point was completed.

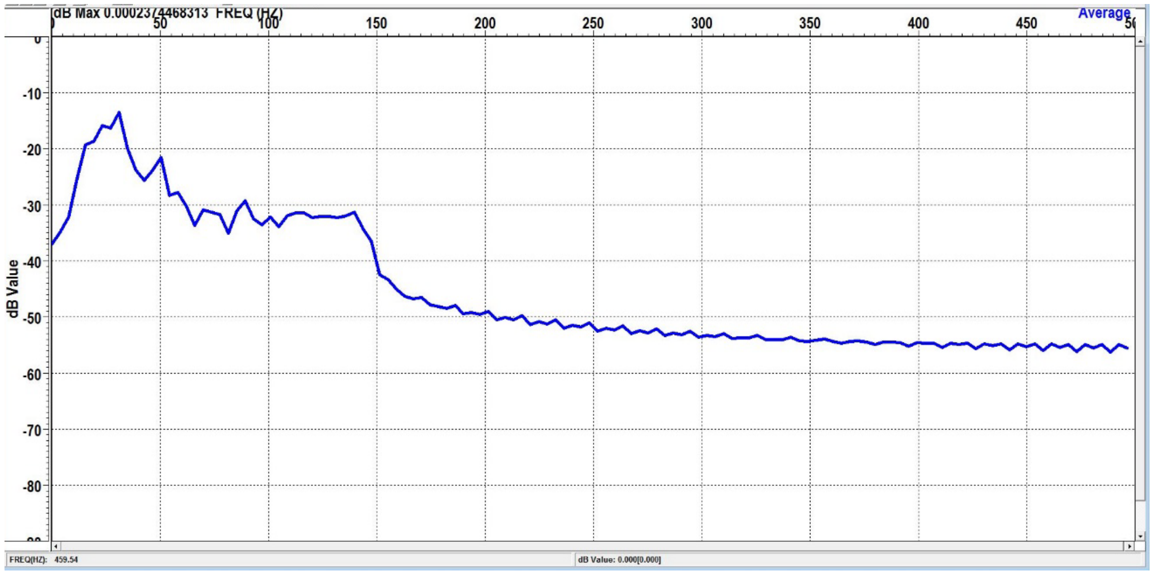


FIG. 19. The amplitude spectrum around some of the reflectors seen in the left part of Figer 18.

The non-reflection seismic activities included VSP and a very small refraction survey using the Geode system, a resistivity survey and GPR. However, the data quality from the GPR was poor enough that the instructors decided to turn it into just an R by running the units on their side and use targets build from wood, foam and a radar reflective backing.

## CONCLUSIONS

Data from all CREWES field projects are available to sponsors upon request.

The Brooks Field Research Station is a bit further to drive to than the Priddis test site, but the data quality there is far more interesting. There will be many more opportunities to perform experiments there as the CMC research group will be using it for a long term study.

Earth Science for Society is great opportunity to get future generations involved and interested in geoscience. It also provides a very useful means of communicating with the public that might not be aware of many aspects in geology and geophysics.

The University of Calgary geophysics field school is recognized as one of the best. This is due to the access of industry standard equipment and staff with many years of experience. Many students who have graduated and gone to work in industry often refer to it as a highlight while studying at the University of Calgary.


## ACKNOWLEDGEMENTS

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