Out of the office, a brief overview of CREWES field acquisition

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ABSTRACT

CREWES is proud to have access to an ever expanding collection of commercial grade seismic and survey equipment. Most of the CREWES staff are eager to take acquisition ideas out of the office and test them in the field. It is also very beneficial for students to witness how the equipment is used to acquire data and some of the challenges that exist with acquisition. In 2014 CREWES has completed the following acquisition projects: a) a video inspection of the original observation well at the Rothney Astrophysical Observatory near Priddis, Alberta; b) an introduction of the seismic recording system and source to the new students of CREWES; c) a 3C 3D survey at a CO_2 injection test site near Brooks, Alberta; d) the 2014 GOPH549 undergraduate Field School project at the Castle Mountain Ski Resort in Alberta; e) a broadband 3C survey with VSP and a geophone coupling experiment at the Rothney Astrophysical Observatory site.

INTRODUCTION

CREWES has access to commercial grade seismic acquisition equipment that is used for research purposes. There are also two fields owned by the University of Calgary conveniently located less than an hour's drive from campus. This location is home to the two new test holes installed last year (Hall et. al., 2013). This is where the Rothney Astrophysical Observatory is located. A map pointing to the location of these fields can be seen in Figure 1.

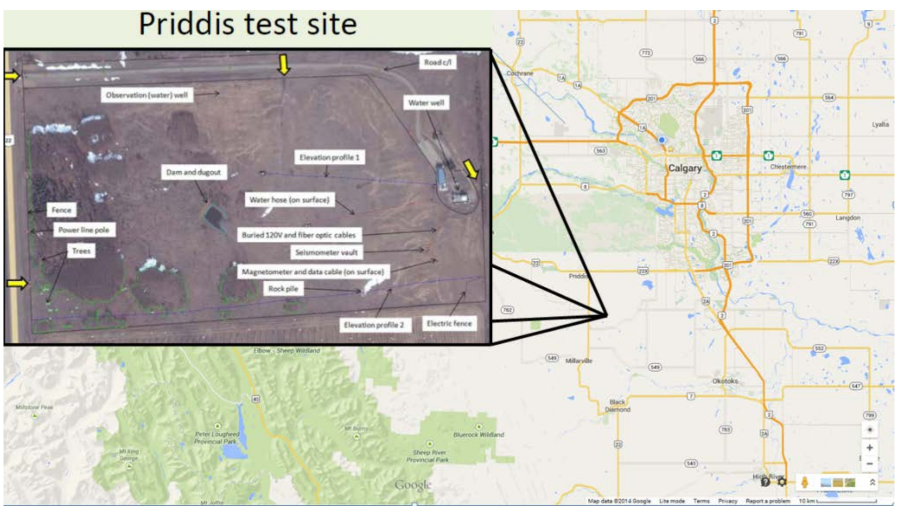

FIG. 1. The Priddis test site's location in relation to Calgary, Alberta.

The first project this year was to try and determine the state of the original test hole drilled at the Priddis test site. This was carried out on January 23, 2014

On February 19, a small 2D acquisition was done as a precursor to further work at the new Carbon Management Canada (CMC) test site near Brooks, Alberta.

The week of May 12 a much larger survey was performed at the Brooks CMC site.

The next project was held at the Priddis test site on the first Friday in June and was a simple demonstration of some of the acquisition equipment and our vibroseis source.

As with years past CREWES once again provided support for the GOPH549 field school taking place during the last two weeks of August.

Finally, in late October/early November an experiment was carried out at the Priddis test site using the permanently installed geophones down Test Hole 1, the fibre optic US Seismic Inc (USSI) system down Test Hole 2 as well as several surface sensors.

EQUIPMENT

CREWES has access to several commercial grade acquisitions systems that are used for research. This allows for staff and students to gather data based on theories and have much data on hand to test seismic processing methods.

The largest system currently accessible to CREWES is an Aram Aries (now Inova) system. This system can be configured to be used with 1C geophones and 3C geophones. This is a cabled system requiring that all ground equipment be connected to a recording system computer, called a Seismic Processing Module Lite (SPML). Although this system is made portable to be used in remote locations it is semi-permanently mounted into a box on the back of a Ford 450 truck, known as the recorder. The ground equipment is typically transported on the back of two Ford 350 trucks.

They system can be broken up into two parts: analogue and digital. The geophones themselves are traditional analogue sensors. The signals from the geophones are transmitted via cables to a Remote Acquisition Module (RAM). A typical deployment of these can be seen in Figure 2. The RAM then digitizes this signal and transmits the digital information to the computer in the truck using the same cables that the geophones are connected to. As this is a cabled system the raw data from a shot can be seen almost instantly in the SPML. This is vital for data QC and teaching purposes. This system can be used with a multiple of different seismic sources.

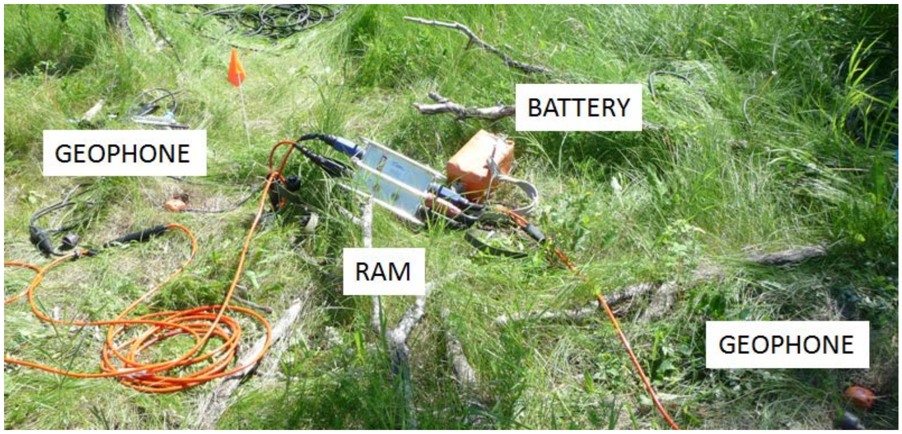

FIG. 2. A RAM and geophones deployed.

On a slightly smaller scale there is the Geometrics Geode system. This system is highly portable in that it can be carried into remote locations by a small team. This system is typically used with a hammer or thumper source and used for refraction surveys.

Again this is a system that is cabled and uses traditional geophones. Currently there are five geode boxes available for use and each one is capable of recording twenty four channels of data. Unlike the Aries system the Geodes use two different cables for the analogue receivers and digital data transmission. All data is transmitted and recorded on a laptop computer such as the one in Figure 3. Each box requires twelve volts to power them.

FIG. 3. The laptop recording Geode data and a sing Geode box.

The US Seismic System Inc (USSI) three axis fibre optic downhole geophone system that was purchased in 2013 is still new and was used on the surface during a receiver test last year (Bertram et al., 2013). Shortly after it was sent back to USSI for upgrading.

The cable that the sensors are connected two is now armoured with steel making it more robust. A nitrogen driven clamping system was also installed around all the sensors. This can be seen in Figure 4.

FIG. 4. The USSI fibre optic geophone inside it's clamping housing.

Typically the above mentioned systems are used with controlled seismic sources. The source that typically travels with the Aries system is an Industrial Vehicles Inc Mini Envirovibe in Figure 5. It is small enough to fit on a trailer and be pulled by a Ford 550 truck. It allows CREWES to use a vibroseis source in sensitive and urban environments. This Envirovibe is interfaced with the recording system by a Pelton VibPro. New for this year the VibPro was upgraded with a GPS card for timing. This makes the Aries system compatible with nodal systems.

FIG. 5. The IVI Envirovibe source.

The next step down is the thumper trailers. The original is a hydraulically driven elastic weight drop in Figure 6 is used as a p-wave source. This hasn't been used as much lately as a newer thumper was designed and constructed by Malcolm Bertram and Eric Gallant around a compressed nitrogen spring system. This thumper, in Figure 7, has the ability to tilt up to forty five degrees to provide a p-wave source.

FIG. 6. The older elastic weight drop p-wave source.

FIG. 7. The new nitrogen spring s-wave source.

Even smaller is the classic hammer and plate seismic. This simply consists of a Geometrics hammer switch trigger attached to a sledge hammer like the one in Figure 8. This is typically used with the Geode system.

FIG. 8. The Geometrics trigger attached to a hammer source.

New this year is a wireless trigger system. This can be used with the hammers or the thumpers to transmit a trigger system wirelessly. An interface with the Aries system is in the works.

Also available is a differential GPS system that was purchased new in 2012 as an upgrade from the previous system. It works much better in finding satellites than the old one as this one is compatible with the Russian satellites as well as the American. However, it has been found that the battery life is not as good and the system does not have a built in battery charger. The battery doors seal tight to the units and are difficult to remove leading to some unhappiness when it comes time to swap/charge the batteries.

The differential GPS works by using a base station and a rover. The base station is set up at a "known" location. The base station knows where it is either by taking an average of its GPS location over a certain amount of time/samples. It could also know its location from a previous survey or even be set up over an official survey monument. The base then compares its known stored location to the location it is receiving form the GPS satellites and transmits the difference, known as corrections, over a radio. The rover GPS, seen in figure 9, receives these correction and provided that it is using the same satellites as the base station applies these corrections to its GPS location. The result is an up to centimetre accuracy in GPS location.

FIG. 9. The GPS rover.

CREWES also has a shared ownership of a Pulse Ekko Pro ground penetrating radar system.

SAFETY AND FIELD READINESS

With safety awareness becoming more prominent in today's society work must be don't to ensure that all field work be carried out in a safe and sensible manor. Before anyone is allowed to leave campus to perform any field experiments a communications plan must be drawn up such that everyone in attendance will have a plan of action in case of emergency. Coinciding with this is the hazard assessment that identifies the potential dangers of the environment and equipment being used. This assessment also outlines the steps to be taken to deal with these hazards.

Before any work happens in the field a tail gate meeting is held where the hazards identified on the hazard assessment are discussed and any questions or concerns that anybody may have are addressed. CREWES is proud to say that since its beginnings twenty six years ago there has not been an incident where medical attention was required.

All field equipment is stored on campus and can easily be loaded onto the trucks and taken to the field. Although CREWES tends to use this equipment often other research groups use it as well. The Geode system is popular for its portability and the differential GPS system get used regularly by other research groups and the department of Geoscience.

FIG. 10. Steel toed boots, high visibility vests and hard hats are standard required personal protective equipment in the field. Gloves, hearing and eye protection are used as needed.

PRIDDIS TEST HOLE INSPECTION

The original test hole at the Priddis test site was installed in 2007 for use with various well logging experiments (Wong et. al., 2007). Questions had been raised as to how well this the casing on this test hole has stood up with some wondering if the casing has failed at all. CMC has recently decided to install coil tubing in the well (Bertram et. Al., 2014) and as such it was decided to inspect the well visually. A camera designed just for this purpose was acquired from High-Definition Seismic Corp based in Cochrane. A video to USB adapter was used to record the video directly onto a computer within the recording truck.

Since this was done in January it was still winter and the field was full of snow. This limited how close we could get the truck with the camera winch system on it to the test hole. Fortunately this system was designed for fairly deep wells meaning that the cable was easily pulled by hand across the field to the test hole.

A portable twelve volt screen was also brought along so the person operating the winch could see the same image that was being recorded onto the computer. The camera was lowered into the well and after a few minutes found the water level in the ground, Figure 11. A few minutes more and it was at the bottom of the test hole. The casing was visibly intact.

FIG. 11. The light from the down hole camera system being reflected off the water.

BROOKS CMC SITE

Carbon Management Canada has entered into an agreement to have access to land near Brooks Alberta as a test site for CO_2 injection and monitoring (Lawton et. al., 2014). As this is a new site and the conditions were not known a small 2D survey running North/South was conducted to determine what kind of data quality could be acquired. This was done in February while there was still snow on the ground and a wind with a cold bite to it. This trip was successful and yielded promising results.

CREWES returned to this site the week of May 12. In cooperation with Inova and Tesla Geophysical a 3C nodal system (Inova Hawk) was deployed as the main recording system. Inova expressed interest in performing some side by side tests between receivers. The Aries system was used with 1C geophones while the Hawk used 3C geophones. The new Inova system recorded using new digital sensors. The comparison was done with the system that Inova has created to replace the Aries, Figure 13.

Two North South receiver lines of the Aries system, the new system and the Hawk system were deployed. While the Hawk nodal system was still being set up for the rest of the field the two Tesla Envirovibes were used as the source along these two lines. The vibes worked in unison in a nose to tail configuration with the source flag between them, Figure 12.

FIG. 12. The Tesla vibrators running nose to tail.

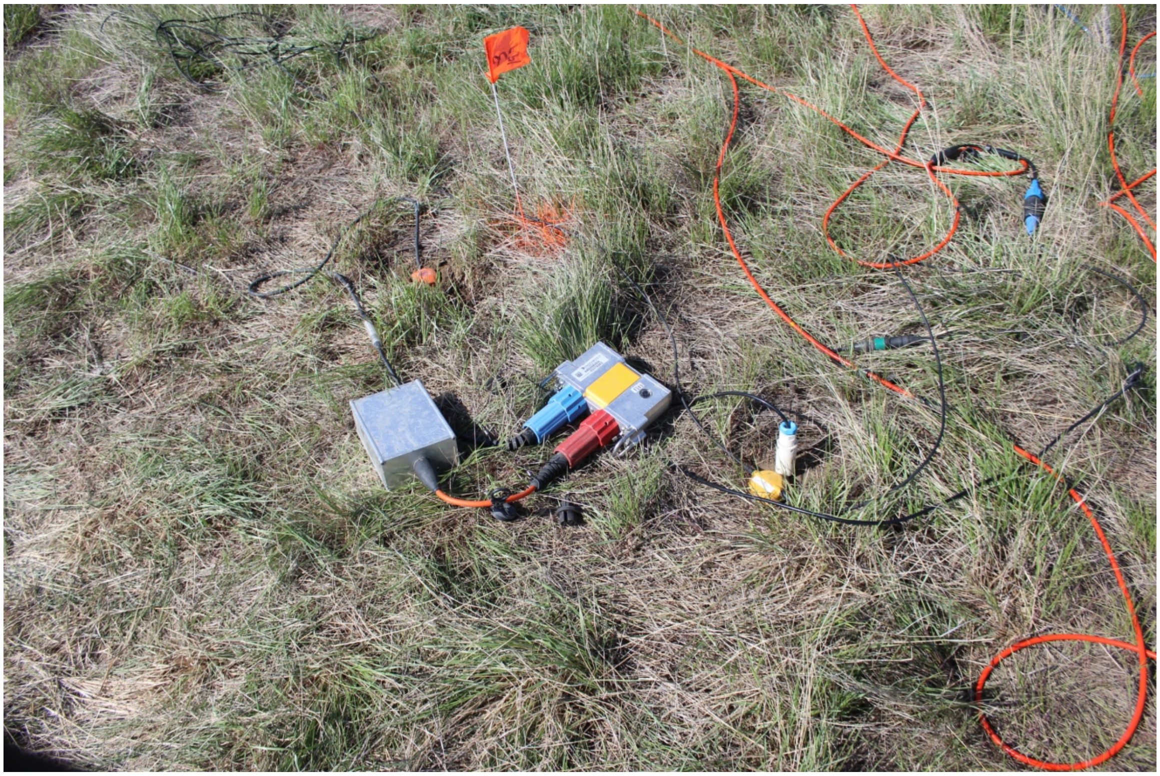

FIG. 13. The comparison of receivers, 3C analogue geophone connected to the nodal system, and an analogue geophone connected to the Aries, and a new digital sensor.

While this test was running the Tesla crew deployed the remaining Hawk nodes, Figure 14. The cabled systems were left in place for QC use and to determine wind noise. The vibrators switched from a nose to tail configuration to a side by side configuration, again with the source flag between them, Figure 15.

FIG. 14. The Hawk nodal system in the data harvesting/charging trailer.

FIG. 15. The Tesla vibrators running side by side.

TAKING THE NEW STUDENTS TO THE FIELD

CREWES has a large number of students and those that complete their education and move into the work force are replaced by new graduates. It is important to CREWES that the students are aware of the capabilities of carrying out real world acquisition experiments. For this reason it has become a yearly routine to introduce the new students to some of the equipment that CREWES has access to. This “mini field school” lasts one day and has the students lay out a small 2D spread, Figure 16, and use the Envirovibe as a source simply as a demonstration of how basic seismic data is recorded, Figure 17.

FIG.16. The cabled Aries recording system deployment being demonstrated to the new students of CREWES.

FIG. 17. The new CREWES students acquiring seismic data.

FIELD SCHOOL

CREWES provides equipment and staff with years of experience to the Geophysics 549 Field School run by the department of Geoscience at the University of Calgary. This year field school was held on the last two weeks of August. This field school is thought of as a highly desired course by those in industry. It provides a very valuable experience to the students so they have a much better understanding as to how data is recorded. The CREWES staff that attends also find it to be a very rewarding time.

This year the field school was held at the Castle Mountain Ski Resort. This is a wonderful location located at the base of a mountain. Since it isn't ski season the hostel and townhouses are available for rent. The activities were split into two main groups. One group stayed behind at the resort to perform the refraction survey and VSP as well as some non-seismic tests.

The other group would travel each morning to a location just south of Pincher Creek to perform a small 3D seismic reflection survey using the Aries system and the Envirovibe, Figure 18. Each student was involved with the setup, recording, and takedown of equipment. This reflection survey also required the use of the differential GPS to accurately locate the receivers and sources, Figure 19. An aerial view map was created using these GPS point and can be seen in Figure 20.

FIG. 18. Students get their first look at a freshly acquired seismic record.

After the acquisition part of the class is done the students return to the classroom to do some analysis of the data they acquired. An example of a single raw data shot is shown in Figure 20. This only has a filter applied.

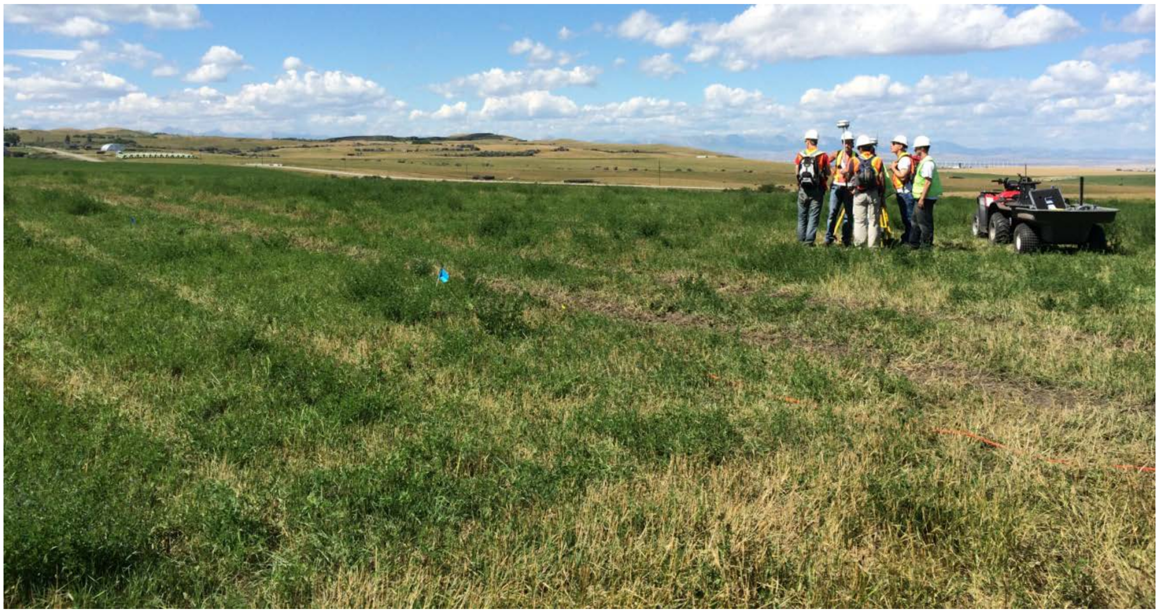

FIG. 19. Field school student learning the set up and operation of the differential GPS system.

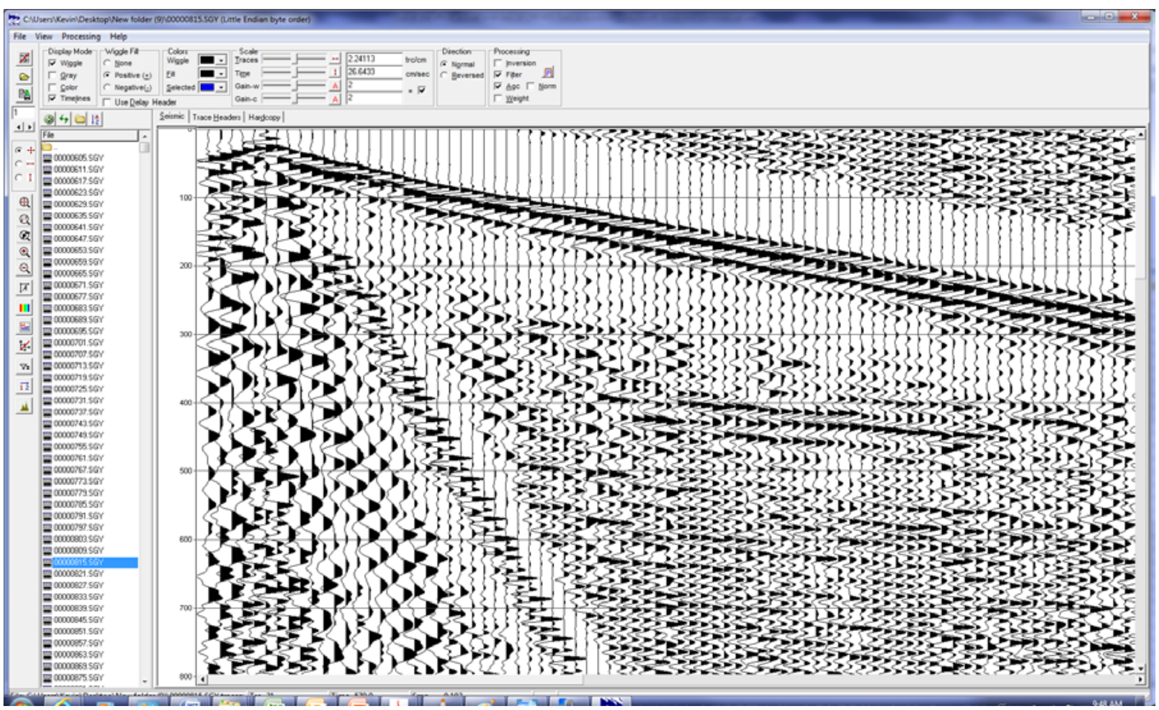

FIG. 20. A shot record from the field school acquisition.

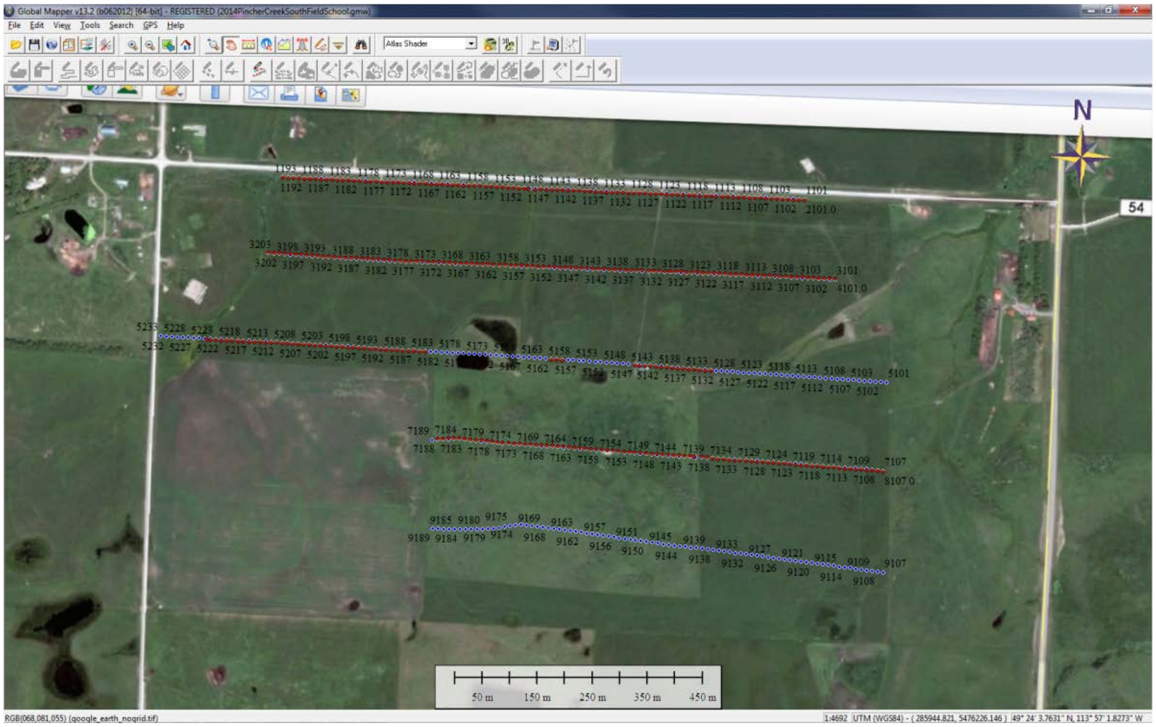

FIG. 21. The aerial view map of the 2014 geophysics field school reflection survey with receiver locations overlaid based on recorded GPS data.

PRIDDIS EXPERIMENT

Every year CREWES tries to perform one experiment at the Priddis test site to try out new ideas and equipment. This year a test was designed with dynamite sources around Test Hole 1 (Hall et. al., 2014). A 3C surface spread was laid out in a star pattern (four lines) centred on Test Hole 1. The geophones permanently installed in Test Hole 1 had been rewired to be in the correct order for this test.

Inova became involved in this test as they wished to do a data comparison with their new receivers again. This time they wanted to compare to the ten hertz high sensitivity geophones as it is a more direct comparison. Again they brought the new wired system and the Hawk nodal system.

This was also the first time that the USSI fibre optic system was deployed down a hole. It was installed into Test Hole 2. Also included were 3C geophones installed into ground screws (used to drill fence posts into the ground) as a geophone coupling experiment. One of these ground screws can be seen in Figure 22.

FIG. 22. The high sensitivity geophone (silver), the new Inova receiver (yellow) and a ground screw installed 3C geophone.

Students volunteered for the opportunity to help deploy and pick up the gear that was laid out, Figures 23 and 24. Some were there to witness the actual acquisition which took place on the Wednesday and Friday of that week.

FIG. 23. Students digging for data.

By far the most difficult part of this job was the synchronization of all the acquisition equipment. CREWES is very fortunate to have had Inova aid with the set up of triggering five recording system at the same time.

By the end of the job CREWES had acquired a broadband data set using 3C surface geophones, 3C downhole geophones and the ground screws. The data recorded by Inova will also be available to CREWES.

FIG. 24. Student picking up the recording gear after the acquisition was complete.

CONCLUSIONS

Data from all these field projects is available to sponsors upon request.

Having the USSI system proven to be capable of syncing with other recording systems will be very useful in the future. Combining this with the shear wave thumper should provide plenty of opportunity for future test hole acquisition experiments.

The wireless trigger system will provide a nice simple way of connecting the thumper to the Aries system allowing for simple smaller experiments to be carried out where there is no need for the vibrator.

The University of Calgary Geophysics field school remains of the best running due to the use of commercial grade systems. This provides a good understanding seismic acquisition and better prepares students for a future in seismic analysis.

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