A brief look at CREWES fieldwork in 2018

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ABSTRACT

CREWES continues to use acquisition equipment to carry out surveys year round. These surveys are designed in house to gather data and test theories. It also provides an excellent opportunity for students and researchers at CREWES to witness first-hand how field data is collected. Furthermore, some researchers have actively been involved in data collection which they have then used for their reports this year.

Acquisition projects that CREWES took part in 2018 include: a) several small surveys at the CaMI Field Research Site; b) although not technically an acquisition project CREWES took part in the 2018 Earth Science for Society event; c) the 2018 Geophysics undergraduate Field School; d) a walkaway/walkaround VSP; e) the deployment and test of a multicomponent DAS layout.

INTRODUCTION

The first project that was carried out took place in late February and the Containment and Monitoring Institute's Field Research Station (CaMI FRS). This was done in collaboration with Inova Geophysical. A 3C surface spread was laid out using Hawk nodes and a new receiver from Inova still undergoing testing.

The second project was a demonstration at Earth Science for Society in March. CREWES had been attending this exhibit for several years now. This is a simple demonstration of some of the tools that are used for seismic acquisition and monitoring.

The third project was a survey involving 3C receivers and an S-wave source at the CaMI FRS in June. This used a 3C surface spread and a 3C land streamer towed behind the source.

The fourth project was a demonstration for visiting researchers from the Norwegian University of Science and Technology (NTNU). This was done in early August.

The fifth project was the University of Calgary's undergraduate field school in lat August. This class introduces students to real seismic acquisition and raw data. A 3D survey was set up with 1C geophones spaced at ten metres with line spacing of one hundred metres.

The sixth project was a large walkaround/walkaway VSP. Receivers used for this project include 3C geophones on the surface with a spacing of ten metres, 324 3C vectorseis receivers installed in the observation well with a spacing of one metre, and the permanently installed fibre loops.

The final project was testing a prototype DAS array buried on site. A DAS interrogator was used to record the fibre data and 3C geophone were recorded using the Hawk nodes. The Envirovibe was used as a source.

TOOLS

In 2005 the University of Calgary acquired a 600 channel seismic system. This equipment is maintained by the seismic group and tends to be used by CREWES more than any other body at the university. The system consists of:

- 600 1C SM24 10Hz geophones
- 75 Aries eight channel Remote Acquisition Modules (RAMs)
- 75 Aries single component cables with 15M spacing
- 10 Aries Line Taps
- An Aries Seismic Processing Module Lite (SPML) recording computer
- 100 batteries

This setup also includes the necessary interfaces to control both vibration and impact/impulse sources. As well as all these there are also several baseline cables and jumper and splitters to run the system in several different configurations. Since this system's purchase it has upgraded and expanded to now include twenty four channel boxes, along with three component cables and three component geophones, Figure 1.

FIG. 1. One of the field trucks loaded up with Aries 3C gear ready for deployment.

At the same time that the Aries system was acquired a Geometrics Geode system was purchased. This system is more compact and portable for use in more remote areas. The current setup has six Geodes that record twenty four channels of data. This data is not stored in the Geode but is networked to a ruggedized laptop for control and data recording. The receiver spacing on the cables is much shorter than the Aries and this system is typically used for refraction surveys.

Also available is a Geostuff downhole tool. This is a three component geophone that can be used with either the Aries or the Geometrics systems. Typically it gets used with the Geodes. The downhole tool has an electrically driven bow spring clamp to secure it against the walls of an observation well.

The most recently acquired recording system belongs to CMC and is the Hawk nodal system produced by Inova Geophysical, Figure 2. This system is essential self contained nodes that record a single station of three channels. It uses GPS timing and location to orient itself on a pre-loaded survey file. Because these are active all the time instead of just when a shot is being acquired they can be used for monitoring.

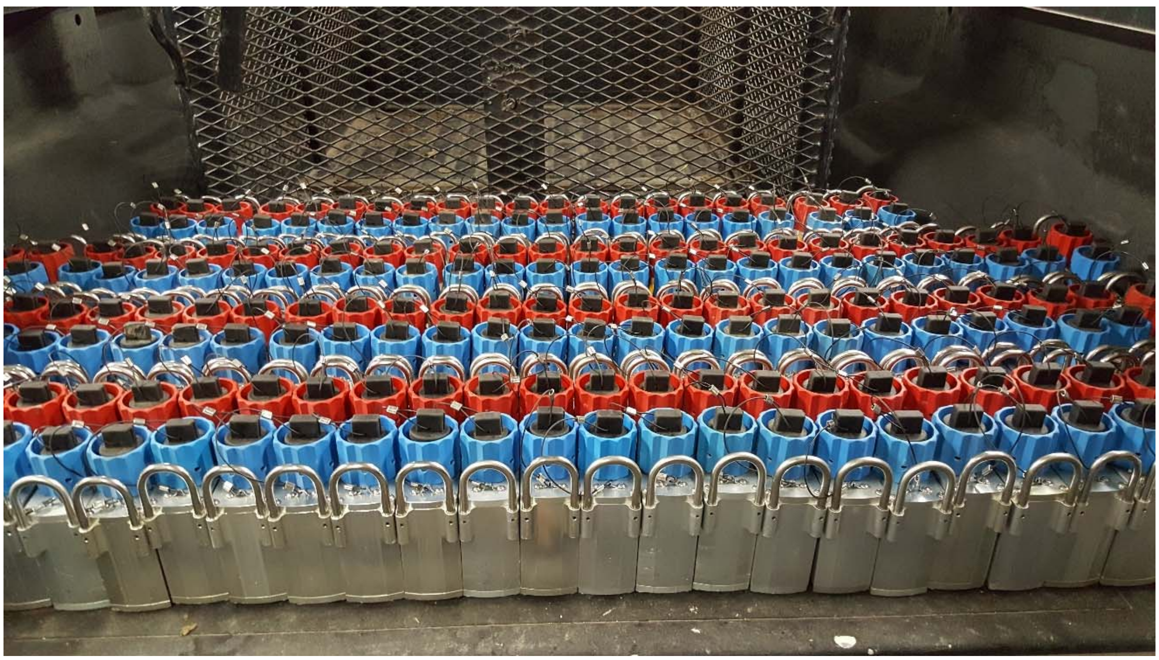

FIG. 2. Hawk nodes loaded in to a field truck waiting to be brought to the CaMI FRS.

To go along with all the seismic receivers there are several seismic sources. The smallest and simplest being the standard hammer and plate. This is typically used with the Geodes in refraction surveys.

The next step up is the S-wave thumper, Figure 3. This thumper is hydraulically driven and uses a nitrogen spring mechanism to drive a hammer against a foot that is placed on the ground. The thumper can be configured to run in P-wave mode with the hammer driving straight down towards the ground. The hammer can be tilted up to forty five degrees to be uses as an S-wave source as well.

FIG. 3. The S-wave thumper tilted to forty five degree.

The poster child source used by CREWES is the Industrial Vehicles International (IVI) Envirovibe, Figure 4. This source has been fairly well used over the years for at least two seismic surveys per year. This year it was freshened up with a new paint job on the cab of the vehicle.

FIG. 4. The vibe sporting a new coat of paint.

The last major component used during acquisition surveys is a Hemisphere differential GPS system. Great accuracy can be obtained by using a base station at a known location transmitting corrections based on knowledge to a rover GPS unit.

LOCATIONS

This year all field work done by CREWES took place at the CaMI FRS. This site is located about two and a half hour drive from the University east on the Trans Canada Highway. This area has proven to have data that is easily readable in raw form during acquisition which is incredibly useful in a teaching environment.

EXPERIMENTS AT FRS PART 1

The first trip of the year was a fairly standard survey at the CaMI FRS in late February. This survey used 3C geophones with the Hawk nodal system. An interrogator was also brought out to be used with the buried fibre. Inova Geophysical also brought a new type of nodal system to be tested, Figure 5. The purpose of bringing these was to test how well they could stand up to field conditions and also do a comparison with the Hawk data.

FIG. 5. The Hawk node with 3C geophone planted next to a new type of node.

EARTH SCIENCE FOR SOCIETY

For several years now CREWES has had a presence at Earth Science for Society (ESFS). This is a several day exhibition that is open to the public to demonstrate some methods and motivations behind geoscience. CREWES brings some of the Seismic Group's equipment for display in an interactive manner. One of the trucks used for acquisition is brought out and is also used to transport all the gear. The display consists of the Geode system showing the readout form several geophones in a four by four wooden beam as well as a single three component geophone connected to an oscilloscope, a ground penetrating radar cart, and an earthquake seismometer with the output shown on a screen, Figure 6. On a Sunday the event typically has groups from local scouting organizations. On the weekdays elementary and junior high school students are brought in and rotated around various stations.

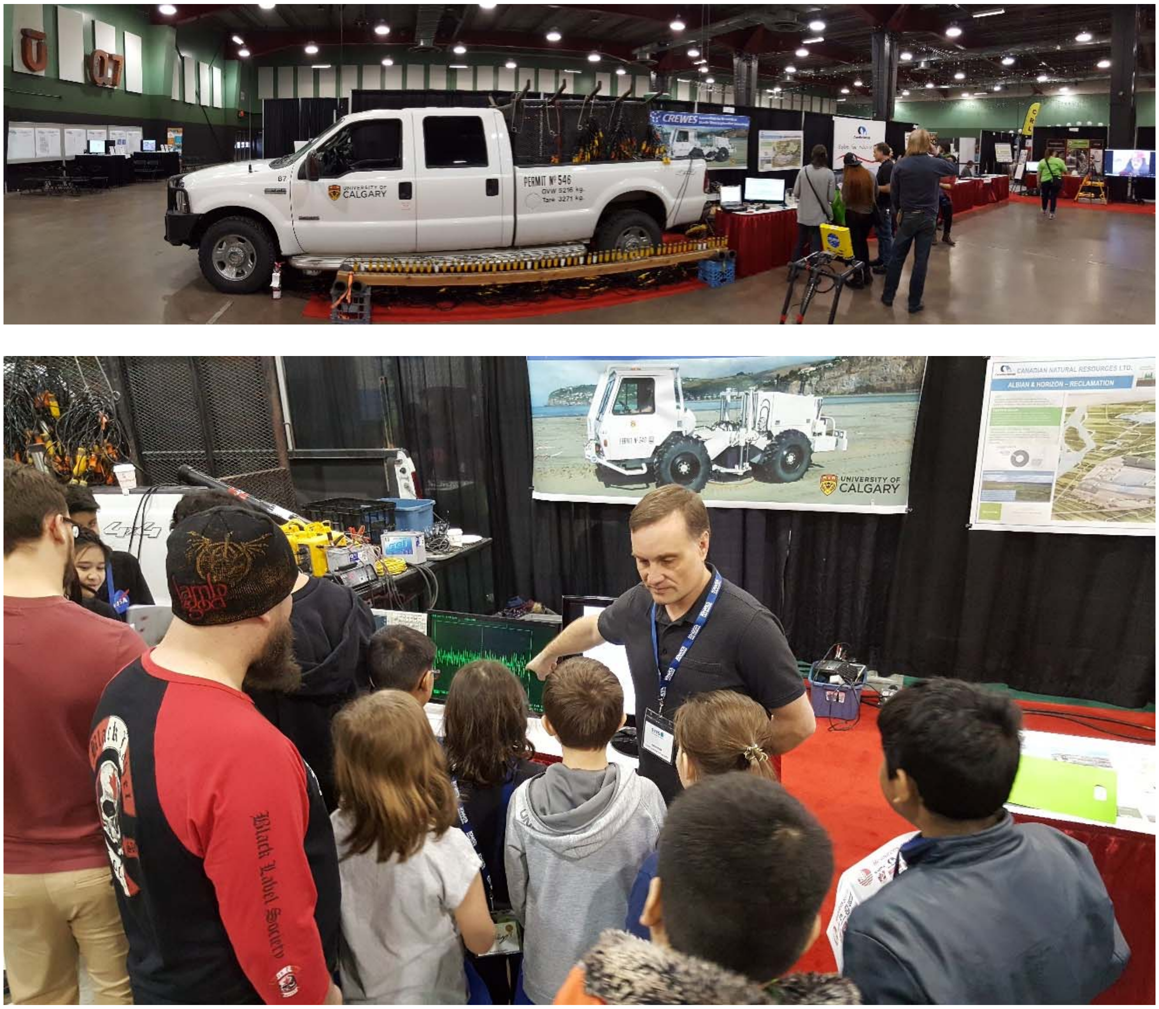

FIG. 6. Top: The CREWES display. Bottom: CREWES Technical Manager Kevin Hall showing students the output of the earthquake seismometer.

EXPERIMENTS AT FRS PART 2

In June two S-wave seismic surveys were conducted. These surveys used an Envirovibe mechanically similar to the one CREWES uses for most acquisition, but with an S-wave mass that moves horizontally instead of vertically. This vibrator belongs to Echo Seismic Ltd. The first survey was recorded using 3C geophones with the Aries twenty four channel RAMs. The receivers were planted along the trench that contains the buried fibre with a spacing of ten metres. The source was run along the same line but with a spacing of twenty metres. The second survey used 3C receivers in a land streamer towed behind the vibe. This streamer had a receiver spacing of one metre with seventy two receivers. For this survey the source spacing was two metres (Lawton et. al. 2018).

In early August CaMI hosted researchers from the Norwegian University of Science and Technology and brought them to the FRS to demonstrate some of the observation and acquisition equipment. Members of CREWES came along to help with a seismic survey. Once again the Aries system was brought along with 1C geophones laid out along the trench. The visitors were able to get hands on with data collection, Figure 7.

FIG. 7. Visiting researchers taking charge of the seismic acquisition.

FIELD SCHOOL

One of the most advantageous aspects of the University of Calgary Geophysics undergraduate program is the inclusion of the Geophysics Field School that is held on the last two weeks of August. For many years this course has been and is considered one of the most important experiences for industry geophysicists. It is worth noting that even though other universities run geophysics field courses they generally do not have access to the scope of industry equipment that the University of Calgary does. By using industry standard equipment students are provided with a sense of scale as well as capabilities and limitations of raw data acquisition. This knowledge is crucial for geophysicists to understand how real world conditions can impact data.

For the past several years the Geophysics Field School has been run in the Pincher Creek area with staff and students residing at the Castle Mountain Ski Resort. This is a picturesque part of Alberta at the base of the mountains and is always enjoyed by all involved. Unfortunately this year that part of the province was under an evacuation warning a week prior to field school starting due to nearby forest fires. Fortunately the CaMI FRS was available and in less than two days all the permitting and utility locate services were switched from one site to the other.

Although the mountains were not in view from the FRS just south of the small town of Brooks there were several advantages to this switch. Obviously being further from the forest fires is a huge safety gain. The onsite trailer/classroom provided a decent area for teaching and shelter from the sun when students were working on exercises. And most importantly the data proved to be far superior to anything that has been recorded at the Pincher Creek location in the past several years. Due to the size and shape of the FRS the seismic reflection survey was changed from a 2D to a 3D survey using single component geophones.

The primary objectives of the field school is to have students participate in field surveys. The students themselves operate the geophysical instruments and other equipment. The students then have to gauge the quality of the data and make some initial assessments of it.

Students are randomly assigned to a group of four or five members. This provides the first challenge as the groups do not get to choose who they work with, providing a more realistic experience for working in the industry. Once a morning safety meeting was completed, Figure 8, each of these groups then spend a day in the field running one of four activities. The four activities are separated into a refraction and VSP survey, an ERT survey, seismic line crew, and seismic recorder crew.

FIG. 8. A safety meeting was held every morning at field school with all the students and staff.

The refraction and VSP survey uses the Geometrics Geode system and the Geostuff downhole tool. Students have to lay out several boxes worth of the Geode system and then use a hammer and plate as the source, Figure 9. The VSP survey is done with a single Geode connected to the Geostuff tool. The tool is then lowered by hand into the observation well and clamped in place. The hammer and plate is used again as the source. Data is collected and the tool is lowered further and re-clamped. The thumper was also used for this survey as it proved to be a much better source when the tool is lower in the well. The thumper was set up with 1000psi in the nitrogen spring.

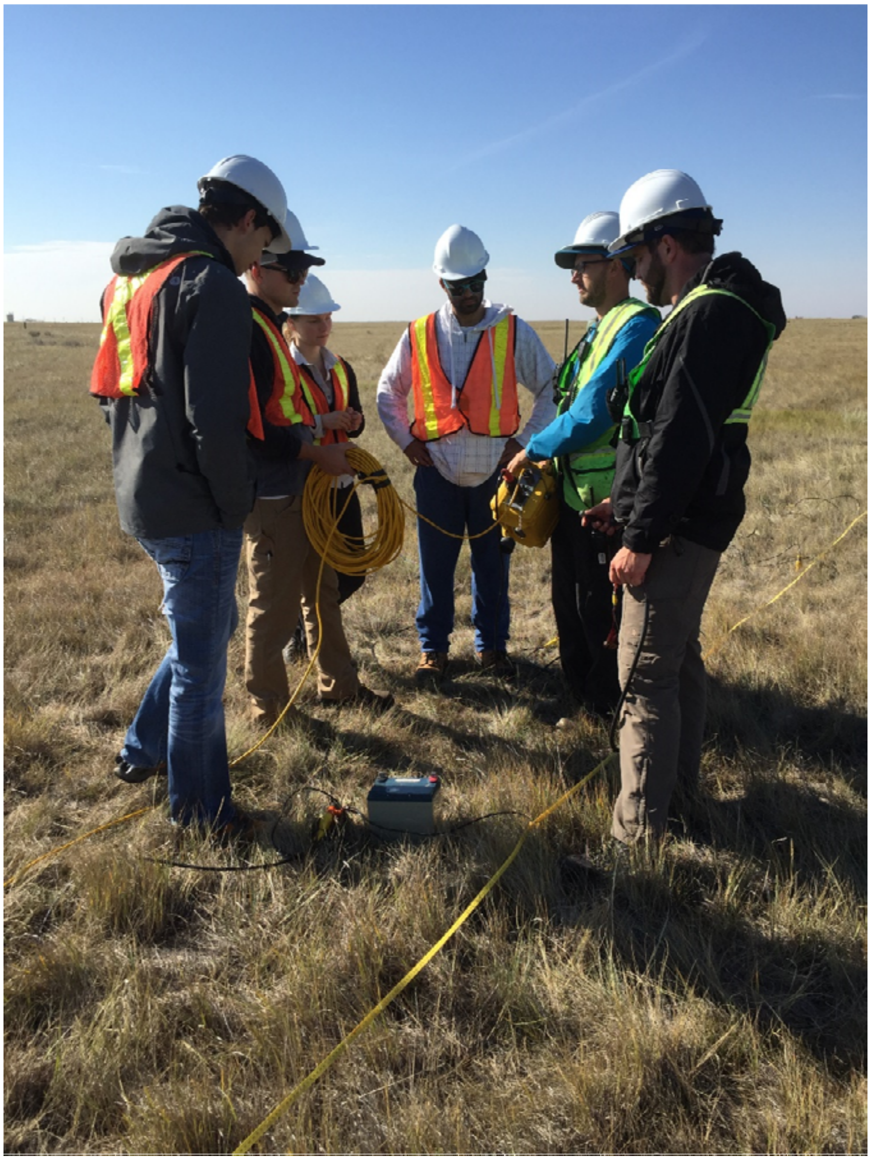

FIG. 9. Field school students deploying the Geode system under the guidance of teaching assistants.

The ERT survey involved setting up the ERT system and planting the electrodes. Once again the students took all the measurements. CREWES did not have much in the way of direct involvement of this activity except for suggestions as to where it could be done.

The seismic line crew had the students chaining and flagging both source and receiver lines. Once a line was chained they would lay out the geophones and Aries RAMs. On average the line crew was able to lay out one line per day. Once five lines were out the first line was picked up and laid out on the other end of the spread. The receiver lines were oriented West to East with the first line to the North. The line crew was also responsible for making chaining notes to give to the recording crew. Line crew would then set up the differential GPS and record the coordinates for each receiver/source point.

The recording crew starts off with instruction on how the seismic survey is structured. With the exception of the first day the recording crew has been on the line crew and should have a basic understanding of how all the acquisition gear outside the truck is laid out and connected. After some instruction the students are put in charge and told to take over the survey. Reflection data is collected and the students are tasked with performing some simple tasks with the data, Figure 10. They are asked to determine first break velocities and confirming that the air blast roughly conforms to the speed of sound in air. Because the data here is so good they can pick reflections and then roughly calculate their depths. While all this is happening the students have to ensure that all the equipment is behaving as it should. When a problem arises it is up to the students to fix. Because of the size of the survey area this is typically done over the radio. One of the goals here is to expose the students to some level of pressure to help them understand that in industry level acquisition there is a need to handle problems quickly and accurately.

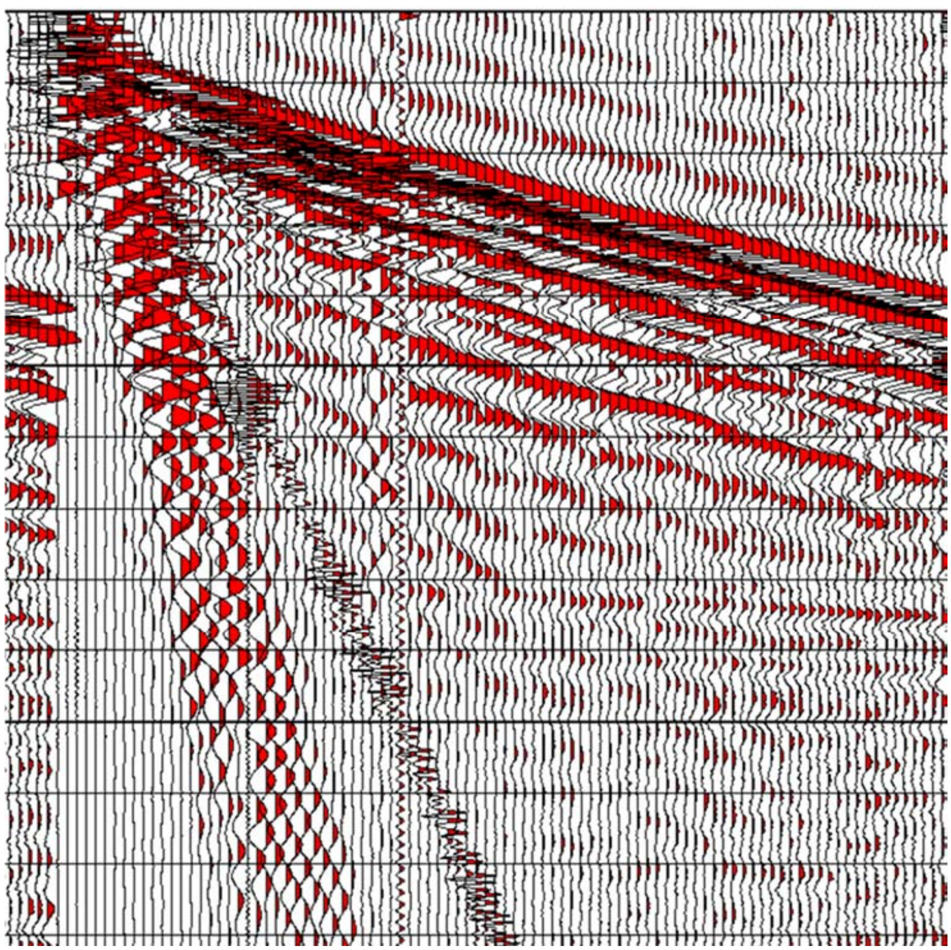

FIG. 10. A sample of raw data from the reflection survey.

Another advantage of the field school location change was that CREWES had planned a fairly complicated survey the week after field school at the same location. This allowed for much of the survey prep work to be carried out during field work. Essentially it meant that one of the CREWES staff was able to flag the source locations for a walkaround/walkaway VSP.

EXPERIMENTS AT FRS PART 3

In September CREWES had organized a series of tests to be conducted at the FRS. The primary test used a large string of 3C receivers down the observation well. At the same time a line of Aries 1C geophones was laid out. The permanently install fibre was also used for receiving data. For a source a Univibe from Inova Geophysical was used. The data gathered is a valuable tool in FWI (Eaid et. al. 2018).

The 3C receivers were loaded into the well using a large crane, Figure 11. These sensors were recorded using an Ion Scorpion system. The permanently installed geophones on the outside of the well were recorded using the Geode system. Both the straight and helical wound fibre were recorded using an interrogator.

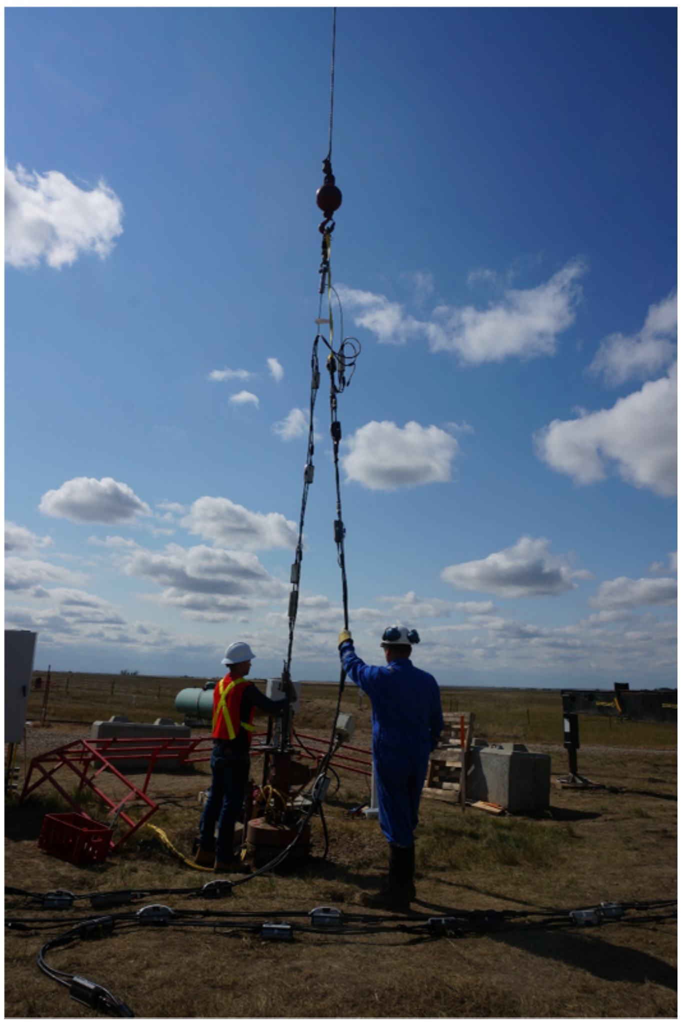

FIG. 11. 3C Vectorseis instruments loaded into the observation well.

Another test that was carried out was using both the Inova Univibe and the Envirovibe were used at the same time at different locations. They were initially set up about five hundred metres apart. First both vibrators were used, then just the Univibe, Figure 12, and finally just the Envirovibe. Once all these sweeps were recorded into the Aries system both vibes were moved up one station and the sweeps were run again. For this experiment the sweep used was 10Hz to 150Hz over sixteen seconds. This data was collected for use in testing deblending techniques (REVEFENCE TRAD).

FIG. 12. The Inova owned and operated Univibe.

Permanent vibrator sources were installed at the FRS and these were spun up for the first time after the VSP was completed. A single geophone from the Aries 1C spread was moved close to the source and had some extra electrical damping applied and was used to create a pilot sweep. Unfortunately there has not been a method of triggering the Aries system when the vibrator starts yet. Instead the Aries system was started manually and then the vibrator was started. Although not ideal data was collected (Spackman et. al. 2018).

The last bit of work that was done on this initial trip was to dig the trench and install a prototype DAS array, Figure 13. At this time, however, there was not a splicer available and the array was not used. As soon as a splicer and an interrogator were available we returned for the final test that will be mentioned in this report. For this test the Envirovibe was used again as a source with the 10Hz to 150Hz sweep. For comparison a 3C geophone recorded using the Hawk system was placed at each point of the array as well as one in the centre (Innanen et. al. 2018)

FIG. 13. CREWES Director Kris Innanen overseeing the installation of the prototype DAS array.

FUTURE WORK

Having access to the CaMI FRS allows for many experiments to be carried out. There will be further use of the multicomponent DAS sensor.

Having proven to be an area with good data there are already discussions of returning the field school to this location in the future. There are also talks of using more geoscientific methods such as gravity measurements.

ACKNOWLEDGMENTS

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