Priddis experiment

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ABSTRACT

A 3C seismic experiment was conducted at the Priddis test site in June of 2016. 3C geophones down test hole Number One were used for recording along with surface receivers. Two receiver lines (Lines 1 and 3) were laid out with one towards the North and one towards the East with a receiver spacing of five metres. A grid of nodal seismic receivers was laid out between the two lines. All nodal receivers had a spacing of twenty metres.

Several source lines were used with this experiment. Two lines coincided with the two receiver lines that were laid out to the North and East from the test hole while a third was shot in between these two, all with a spacing of five metres. There were also three source lines laid out in a quarter circle between receiver lines one and three with radii of ten metres, twenty metres and thirty metres.

INDRODUCTION

Every year CREWES conducts acquisition experiments using available seismic equipment. This year we did an experiment at the Priddis test site located just Southwest of Calgary which is the location of the Rothney Astrophysical Observatory, Figure 1. In 2013 CREWES had two new test holes installed in the North field of the Priddis test site (Hall et al., 2013). This well has permanently mounted 3C geophones installed around the outer casing. This well became a focal point for the design of this survey.

FIG. 1. Looking down to the survey area from the Rothney Astrophysical Observatory.

Having done many surveys at the Priddis test site, including a field school in 2010, there is a fairly good understanding of what to expect data wise. The primary focus of this survey was to test and improve on some of the acquisition equipment. We were also particularly interested in whether or not we were able to use both Aries cabled equipment and the Hawk nodal system in the same survey.

This was also a great opportunity to showcase some of the equipment that we have available to some of the new students. This is an important part of CREWES as it allows students to come up with new acquisition ideas which lead to further experimentation. Having students in the field also provides a source of labour for layout and pickup of the gear, Figure 2.

FIG. 2. Students working hard.

New equipment was acquired this year in the form of Aries 24 Channel Remote Acquisition Modules for three component geophone recording. This was the first time that we have used these particular boxes in the field.

CREWES has a close relationship with Inova Geophysical and around the time of this experiment we were approached to see if we could assist in testing updates for the Hawk nodal system.

PLAN

We wanted to incorporate as much equipment testing as we could in this experiment. The spread was small with an area of only 200 by 200 metres. As we wanted to use the thumper in vertical (p-wave) and angled (s-wave) mode the survey was designed to allow us to shoot into and away from the well. With the thumper being a trailer pulled by a truck the radial source lines would allow for the thumper to be pulled around the well without having to perform any difficult maneuvering. For the straight source lines the thumper would not shoot into and away from the well, but perpendicular to the source line. A plot of the source lines can be seen in Figure 3. Initially the plan was to shoot four circular source lines, but a decision was made in field to only do the three smaller ones. The straight source lines had a shot spacing of five metres. The circular source lines were laid out such that each shot point was five degrees relative to the well.

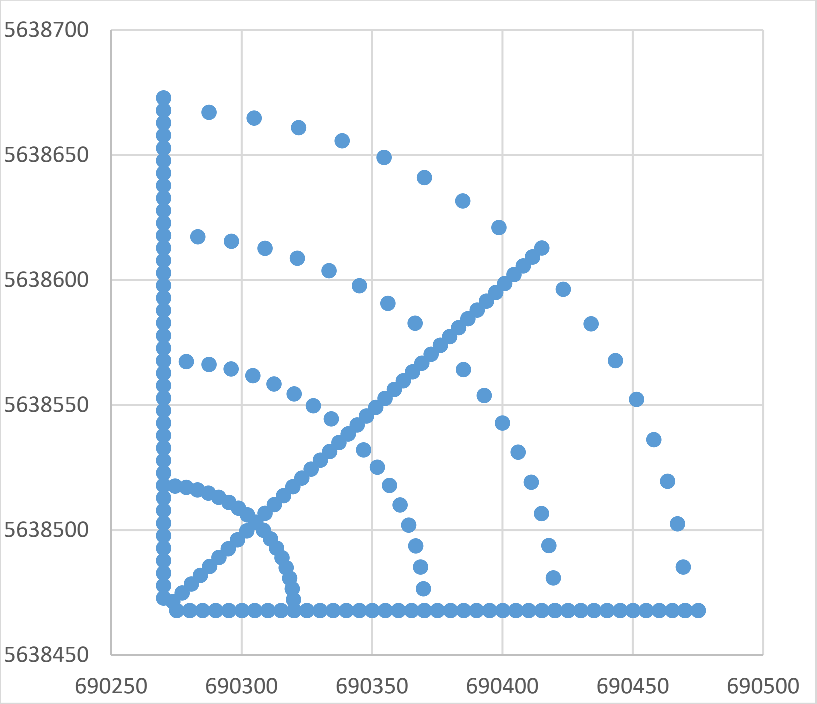

FIG. 3. The planned source lines for the survey.

The receivers were set out in a bit more of a traditional manner. The two cabled lines that were laid out North/South and East/West had a spacing of five metres and coincided with the shot points. The nodes were laid out in a square patch with a spacing of twenty metres, Figure 4.

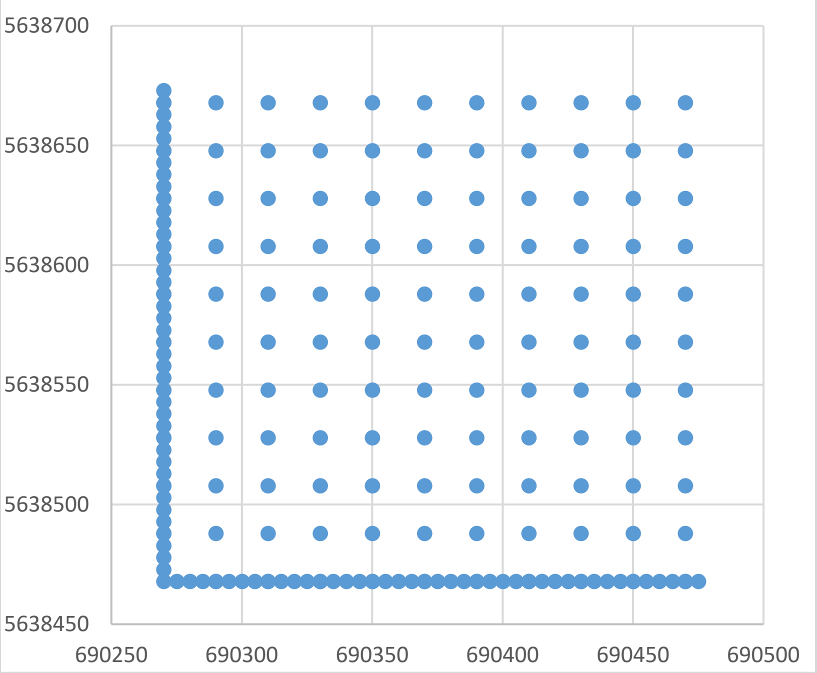

FIG. 4. The cabled and nodal receiver plan.

EQUIPMENT

There was a fair bit of equipment used for this survey. The test hole that we were using for this experiment has Weir-Jones 3C geophones permanently installed around the outside of the casing. These geophones can be recorded using a 1C Aries system by means of adapter boards built by Malcolm Bertram, Figure 5.

FIG. 5. Custom built adapter boards to convert the Weir-Jones downhole geophones to Aries recording system.

The cabled surface spread consisted of the newly acquired 3C Aries RAMs. Unfortunately the Aries recording computer cannot run a mix of 1C and 3C RAMs and we were forced to use two computers. Fortunately a second computer had been donated by MEG Energy to the University of Calgary in 2014. This allowed us to use the computer we normally do for the 3C cable spread and the donated machine for the 1C.

The Hawk nodal system was set up by Inova Geophysical as they wanted to test new firmware and software. As such the Hawk units that were used belong to Inova, Figure 6. However the batteries and geophones belong to the Seismic Group. Inova brought a recorder with the Hawk control system for this survey.

FIG. 6. A pile of Hawk nodes awaiting deployment.

Two sources were used for this experiment, an IVI Envirovibe, Figure 7, and a custom built nitrogen driven shear wave thumper, Figure 8. The Envirovibe has been the primary source of CREWES acquisition for over a decade. The thumper is still considered new equipment and has not yet seen much field time. As such a trigger system to use the thumper with the Aries system needed to be sorted. This was done using Pelton ShotPros in Air Gun mode.

FIG. 7. The IVI Envirovibe.

FIG. 8. The shear wave accelerated weight drop thumper.

As there were now three systems for recording and two sources a way to trigger all the systems accurately was needed. Inova Geophysical had a connection box that they had built to trigger two Aries systems. This box was modified with an extra trigger output that was connected via a cable to the recorder that had the Hawk control system in it. We also used a Verif-i for GPS timing.

A differential GPS unit was also used to record all the receiver and source locations. It was also used in the layout to get the circular source lines flagged.

The thumper also has a new control system that needed to be tested as a proof of concept (Bertram et al. this volume). This system allows for wireless control of the thumper.

EXECUTION

Connection and set up of the cabled systems didn't take much time at all. Once the nodal system was laid out it timing between all the systems was checked and acquisition could begin. The Envirovibe was used first. The three straight source lines were shot and then the three radial lines. Once that was complete the thumper was tested and sent to do the first shot point. This was on the diagonal source line. At the second shot point the thumper had a mechanical failure. Unfortunately a design flaw was found in that after the first hit, if the foot wasn't reseated to the ground the second hit would put a lot of strain on the pin that the mass rotates on. This caused the pin to shear off at this shot point. Not being field repairable pickup was started and the acquisition part of the experiment concluded, Figure 9.

FIG. 9. The sheared off pin can be seen circled in red.

Unfortunately there was an error with the triggering of the Aries system that was recording the downhole geophones. As such time zero was late for several shots.

DATA

The seismic sources were located along two orthogonal, one diagonal, and three radial lines, and recorded on the surface by two orthogonal 3C receiver lines. The offsets ranged up to 280 m, which is inadequate for observing normal move out in the data. We did see a lot of shot-generated noise and reverberations. To attenuate these undesired events and enhance any signal in the data, we applied air blast attenuation, predictive deconvolution and Gabor deconvolution. Figure 10 shows a selection of field shots from different shot lines, and their processed versions. It was not easy to attenuate the very high amplitude coherent noise and some residual noise remains in the processed data.

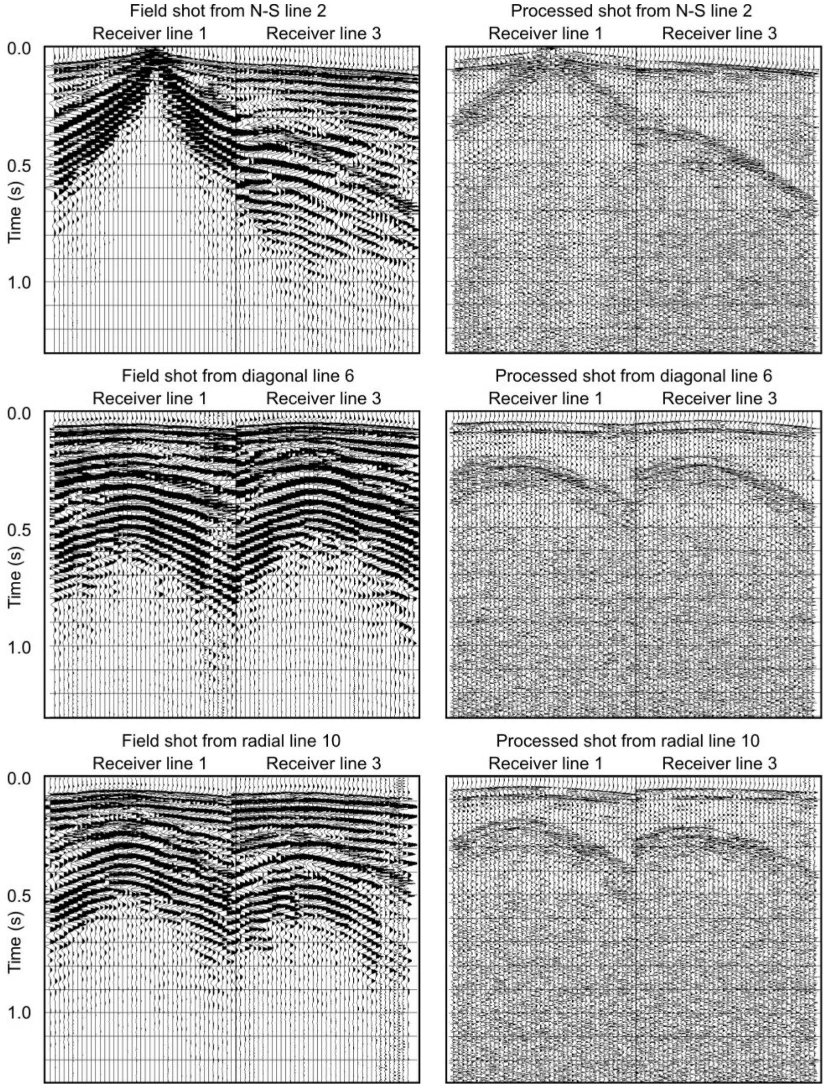

FIG. 10. A selection of shots from the surface reflection data.

We binned the data as a 3D survey and processed the data through to stack even though the survey was designed for instrument tests rather than seismic imaging. We picked first breaks and performed refraction static analysis. Keeping a constant near-surface low velocity of 600 m/s, the solution produced a depth to the refractor and a refractor velocity at each shot point and receiver location. Figure 11 shows the velocities overlain on the contoured refractor depths (thanks, Faranak).

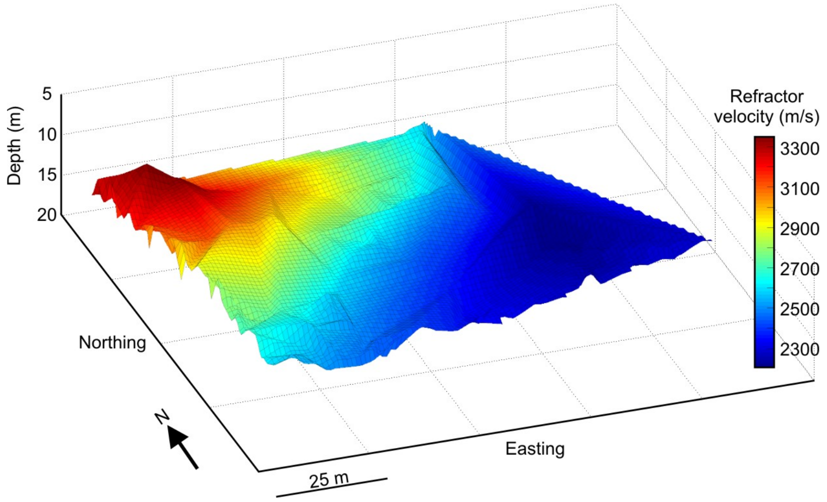

FIG. 11. Near-surface velocity-depth model from 3D refraction statics analysis.

The data were unsuitable for picking a velocity function as the offsets are short and there appears little signal. We used a velocity function from previous processing of seismic data from Priddis to apply NMO and then stack the data. We selected to stack data running along a line parallel to the west-east source line 4, as that is the direction in which we have seen seismic reflectors dipping at 30° (GSC, 1941; Isaac and Lawton, 2010a), and is one of two directions with a high fold stack, the other being parallel to source line 2 (Figure 12).

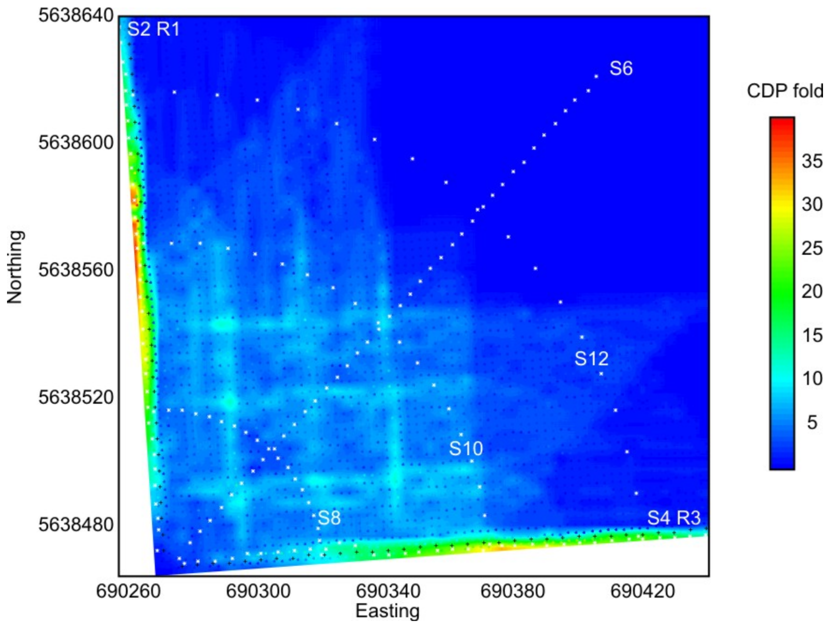

FIG. 12. CDP fold of surface data binned with a 3D geometry. We stacked a line parallel to S4 and R3 as it had the highest fold and the strata dip to the east.

The stacked line is shown in Figure 13. Dipping events can be seen in the top 200 ms (indicated by the yellow oval), and flat events at 1.0 s. This relates well to the structure observed on other data from this study area (Isaac and Lawton, 2010b, Figure 7). The line is too short to be migrated.

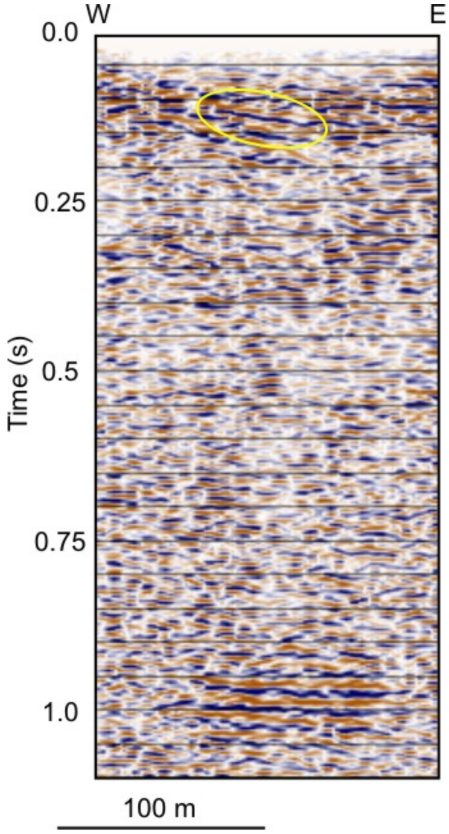

FIG. 13. Stacked W-E line. We see evidence of easterly dipping reflectors (yellow oval).

DISCUSSION AND FUTURE WORK

The primary goals of testing the ability of recording with both the Aries cable system and the Hawk nodal system and using the s-wave thumper were completed mostly successfully. Although the thumper did fail, it was fixed and a smaller survey consisting of a single surface line from the test hole to the North and the down hole geophones was completed successfully (Lawton et all NUMBER).

Unfortunately the data recorded by the downhole phones wasn't of much use.

Future work includes:

- A small survey with source points in a complete circle around the test hole.
- Improvements to the thumper control system.
- Improvements to the thumper trigger system.
- A new interface for triggering more than one recording system with better accuracy

- Possible thumper redesign.

ACKNOWLEDGEMENTS

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FIG. 14. Some of the field service team from Inova Geophysical.

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