GeoConvention 2014 FOCUS adapt refine sustain

Borehole instrumentation and initial source test results at the Priddis Geophysical Observatory

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Summary

Two new test wells were completed at the University of Calgary's Priddis Geophysical Observatory (PGO), south of Calgary. The wells were drilled to a depth of 146 m and were cased with schedule 80 polyvinyl chloride (PVC) casing. One of the wells was permanently instrumented with 45 3C geophones at a nominal 3 m spacing, in addition to single and multi-mode optical fibres. All instrumentation was strapped to the outside of the casing upon insertion into the borehole and was then cemented into place. Two approximately 300 m long 2D surface seismic lines with 3C geophones at a nominal 6 m spacing were acquired at approximately right angles to each other centered on the instrumented borehole. All surface and borehole receivers recorded linear sweeps from an IVI EnviroVibe source, 0.125 kg dynamite test shots, and United Service Alliance accelerated weight-drop test shots. The weight drop source was used to hit the ground vertically, +45 degrees and -45 degrees at each location that it was used.

Introduction

The University of Calgary has surface rights to land located at legal subdivisions (LSD) 3 through 6 of 13-22-3W5, near Priddis, Alberta. The Rothney Astrophysical Observatory (RAO) is located on the centre-east part of LSD 6. Geophysical test well locations are shown as red and white rings in Figure 1. The northernmost well (Well 4) is an existing test well that was drilled in 2007. Well 1 and 2 locations were picked based on relatively flat locations that a drill rig could access, and were further constrained to be 50 m apart in the regional dip direction (70° azimuth; Geological Survey of Canada, 1941), with Well 1 approximately centered on the property. The Well 3 location is intended to be roughly equi-distant between Wells 2 and 4 along approximate regional strike. Wells 1 and 2 were drilled in late September and early October of 2013. Well 1 was cored from 31.5-124.0 m depth, and seismic instrumentation was strapped onto the outside of the casing before cementing. Well 3 was not drilled due to lack of funds, but we are hoping to drill this test well in future.

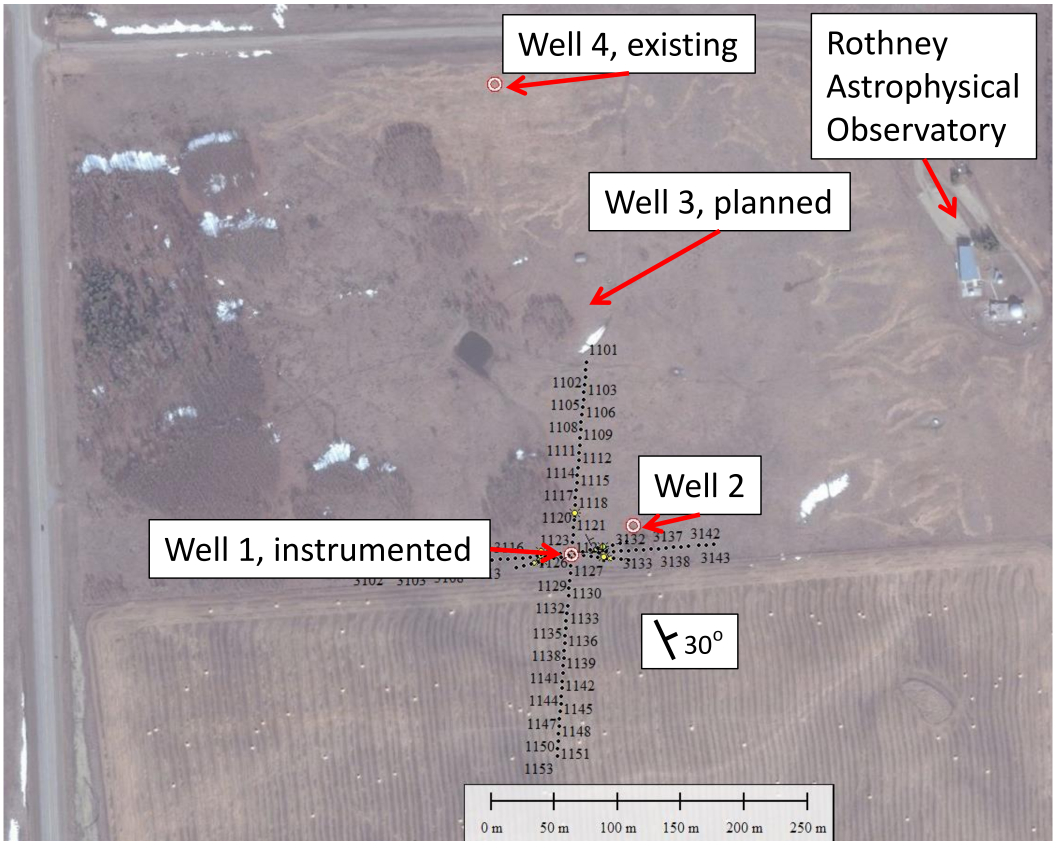

FIG. 1. Well locations. Background image © 2012 DigitalGlobe, 2013 Microsoft Corporation (Bing Maps, 2013).

Method

Twelve downhole geophone cables were available for deployment in Well 1. Each cable has 4 geophones at nominal 10 m spacing, with the exception of cable 12 which only has one geophone. The cables were interleaved as shown in Figure 2 to achieve a 3.06 m geophone spacing in the well. Geophones and optical fibres protected by stainless steel tubing were strapped to the outside of the PVC casing as it was inserted into the well. Geophone resistances were provided by the cable manufacturer, and geophones were tested by measuring resistance with a multi-meter at the University before deployment and after cementing was completed in Well 1.

A seismic program was conducted two weeks after completion of Wells 1 and 2. Linear Vibroseis sweeps (Figure 3), shear wave weight-drop (vertical, $+45^{\circ}$ and -45° thumps; Figure 3) and dynamite test shots were recorded by the single-mode optical fibre and 3C geophones in Well 1, as well as by single surface 3C geophones that were laid out at a 6 m receiver spacing (Figure 1). The dynamite charges were all 0.125 kg. Six shotholes placed single charges at 10 m depth and equi-distant from Well 1, with two of the shotholes drilled vertically, two shotholes drilled at a 30° angle from vertical oriented radially away from Well 1, and two shotholes drilled at a 30° angle from vertical oriented radially towards Well 1. The seventh dynamite shothole had charges vertically spaced from 20 meters depth to almost the surface, which were fired separately from bottom to top.

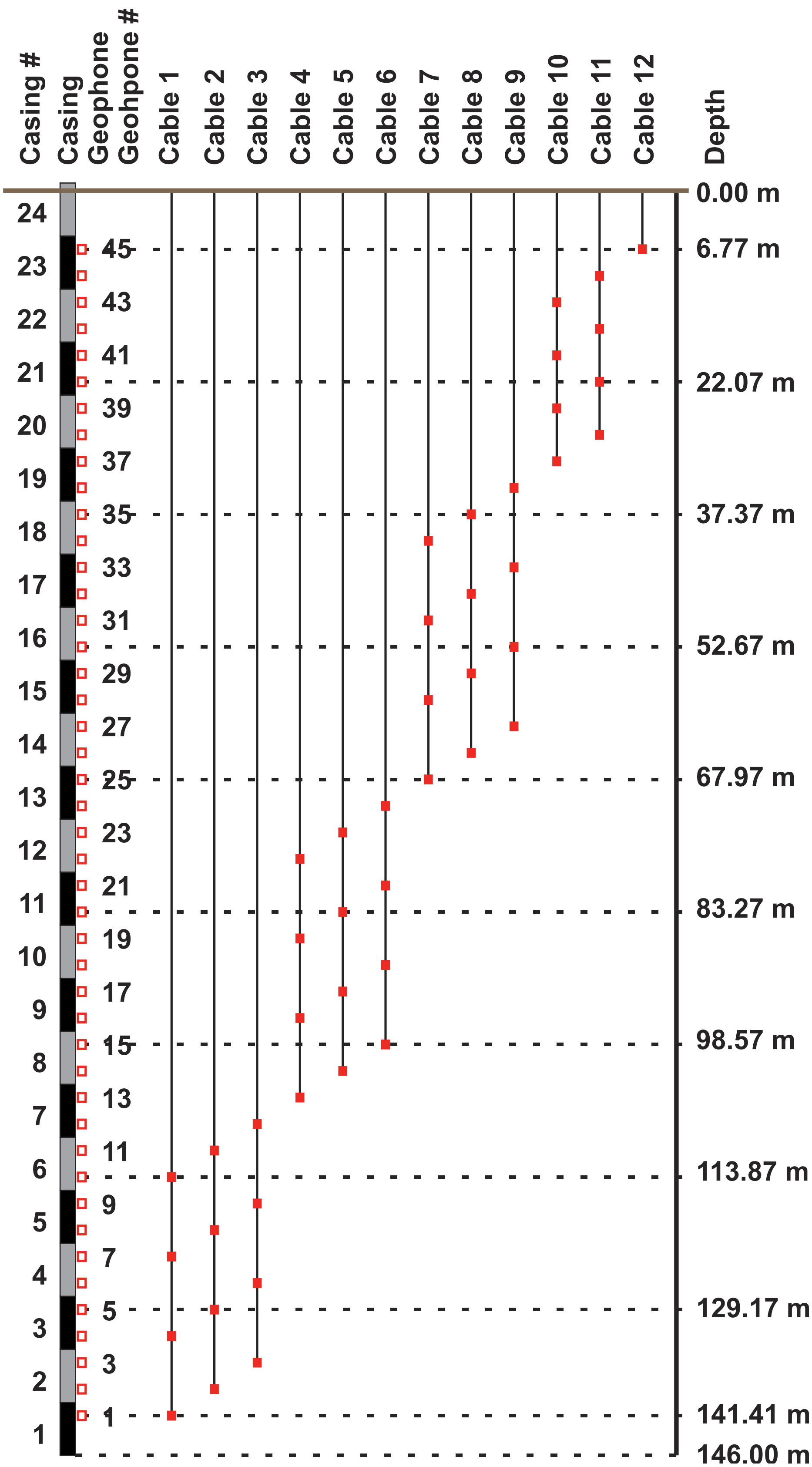

FIG. 2. Geophone emplacement in Well 1.

FIG 3. The Envirovibe and the shear wave weight-drop in the field at the Priddis test site.

Examples

A sample of the data from the first of the dynamite shots is shown in Figure 4. This is the vertical component of the four surface lines 1 (N-S), 3 (E-W), 5 (NW-SE) and 7 (SW-NE) and the first horizontal (X) component of the downhole array. This shot was 0.125 kg at 10 m depth near Well 1.

After applying component rotation to the downhole geophones, it is possible to examine the near offset shots in more detail. Figure 5 shows a gather from a 45^{o} northward thump near the well. The separation of energy between axes is very good, and the near surface velocity information is easy to determine. The measured values from this plot are: P-wave (right panel) 3060m/s; S-wave (centre panel) 623m/s to a depth of 40m then 1530m/s to TD.

Conclusions and Future Work

Geophones that were cemented into Well 1 have, for the most part, survived the installation and are providing good data. The new shear wave weight-drop (thumper) source is providing a good source of shear wave energy for near surface investigations. To date only a small amount of data has been acquired, and more projects are planned at the Priddis Geophysical Observatory to further evaluate the source in terms of available offset range and frequency content, as well as attempting shear wave reflection acquisition.

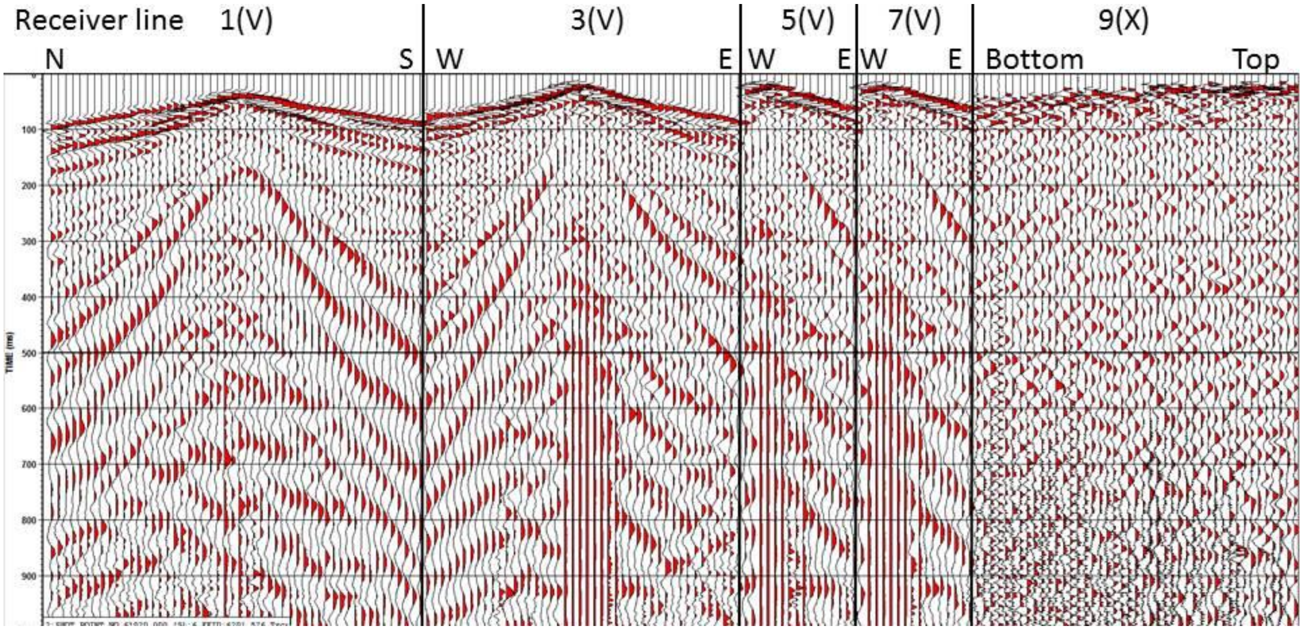

FIG. 4. Example of dynamite gather for shot 6102 (file 620) with 200 ms AGC applied. Lines 1, 3, 5 and 7 are the vertical components of the surface receivers; line 9 shows the X component of the downhole array before re-ordering and rotation.

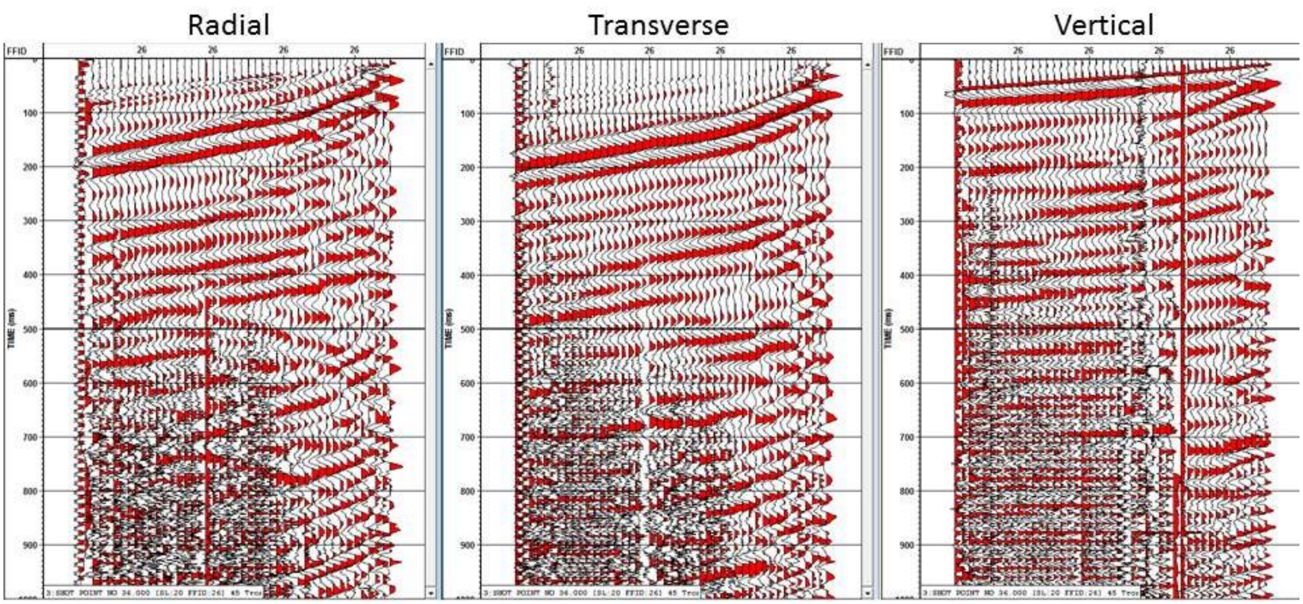

FIG. 5. The gather from a northward thump at a location 2.5m west and 3.7m south of Well 1 (file 26).

Acknowledgements

The authors would like to thank Austin Powder, Carbon Management Canada, GroundForce geoDrilling Solutions, Halliburton, NSERC, Outsource Seismic, SITE, Schlumberger (WesternGeco, Gedco) CREWES staff and all CREWES sponsors.

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