Installation of a vertical pressure cell at the Priddis Geophysical Observatory

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Introduction

Carbon Management Canada and CREWES have installed a vertical pressure cell in Testhole 4 at the Priddis Geophysical Observatory for the purpose of testing down hole equipment. The first application was to test a prototype optical sensor from the University of Victoria that is sensitive to CO2 concentration. The cell consists of coil tubing, sealed at the top with access ports for CO2 and test instrument tubing, allowing the pressure to be taken up to 35 MPa, thereby simulating various reservoir depths. By releasing CO2 or other gas bubbles into the bottom of the coil tubing, the new sensors can be tested and calibrated. The facility continues to be developed.

Background

Testhole 4 at the Priddis Geophysical Observatory was drilled in 2007 and cased to a depth of 127 m with PVC casing grouted with bentonite (Figure 1) (Wong et al.). More recently seismic data quality obtained in the well has appeared to deteriorate in quality, possibly due to bentonite being washed away by ground water. This made it a good candidate for the installation of a vertical pressure cell.

FIG 1. Well 4 before the installation of the coil tubing. The bentonite grout between the PVC casing and the steel conductor casing is visible. The ID of the PVC restricted the size of coil tubing that could be inserted to 2.875 inches, resulting in an available ID of approximately 2.5 inches. This allows for a 2 inch diameter probe to fit alongside a 0.25 inch tube for gas bubble insertion.

The installation

Steel coil tubing with a cap welded onto the bottom has been inserted into the well (Figure 2), a centralizer installed (Figure 3), and a bell nipple with threads for a flange has been welded onto the top of the coil tubing (Figures 4 and 5).

FIG 2. The coil tubing being inserted into Well 4

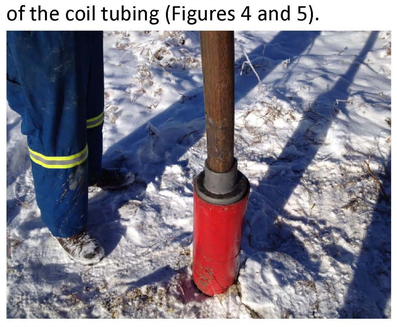

FIG 3. The centralizer in place on the coil tubing.

FIG 4. The bell nipple being welded onto the top of the coil tubing.

FIG 5. The finished coil tubing ready for the wellhead equipment to be installed.

The completed pressure cell

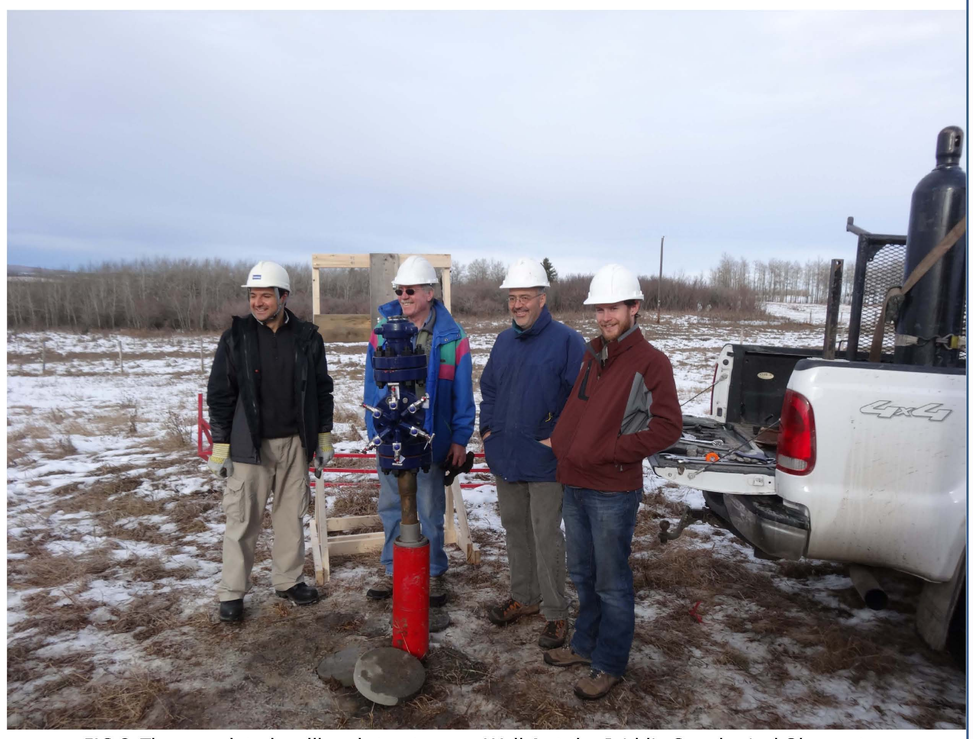

FIG 6. The completed wellhead structure on Well 4 at the Priddis Geophysical Observatory

FIG 7. Detail of the well head

The completed well head

The wellhead structure is shown here (Figures 6 and 7). The shut off valves on the left in Figure 7 are for fluid control and will be used:

a) to control the level of water in the well to ensure that there is minimal head space above the water requiring pressurizing,
b) for nitrogen (or other gas) injection to create the desired pressure regime and
c) for a precision pressure relief bleed valve that will maintain the pressure in the well as carbon dioxide (or other gas) is injected into the bottom of the water column.

There are six valves available of which 4 will be used for the above purposes, leaving two for future use.
On the top of the well head is a knock-on cap with 5 ports for Conax fittings which can accommodate tubing of 0.125 to 0.375 inches. These fittings are rated to 10,000 psi. The unused ports are sealed with plugs.

The next phase

The next procedure to be carried out on site is to pressure test the cell to make sure that there are no leaks. This will be done by using either compressed air or nitrogen to bring the pressure up in stages to the expected maximum operating pressure, with a lengthy pause at each stage to monitor for pressure loss anywhere in the system. When at maximum pressure, the cell will be held at this for enough time to monitor for pressure changes due to other factors such as ambient temperature changes.

Acknowledgements

This system was designed and installed with the assistance of many people.

- Sanjel Corporation provided the coil tubing and the services to install it in the well
- Select Energy Systems Inc. designed, built and installed the well head equipment
- CREWES provided staff to monitor equipment installation and other logistics
- Carbon Management Canada provided funding for the pressure cell
- University of Victoria provided the optical sensor and personnel for the first test of the cell (unpressurized)

References

Wong, J., Miong, S., Gallant, E., Bland, H., Bentley, L., and Stewart, R., 2007, VSP and well logs from the U of C test well, CREWES Research Report, **19**.

The first test of the pressure cell

The first test using the pressure cell was completed November 20 and used the cell as an open pipe before the well head structure was installed. This test was of the optical fiber sensor developed by the University of Victoria (Figures 8 and 9). The first measurement was to test the sensor as a bubble detector to ensure that it could differentiate between different fluids. For this test the sensor was set at various depths up to 25 metres, and a 0.25 inch stainless steel tube was inserted to a depth of about 40 metres and used to bubble nitrogen into the water column (Figures 10 and 11). The flow rate was adjusted to various settings to test the sensor. Figure 12 shows the winch used for this test setup, Figure 13 the electronics and laser source for the sensor, and Figure 14 two screen shots of different bubble counts.

FIG 8. The internal structure of the sensor.

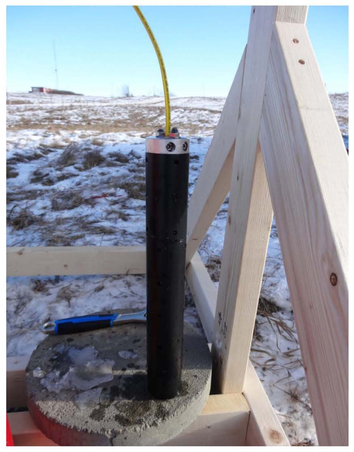

FIG 9. The assembled probe ready to be deployed.

FIG 10. The nitrogen bottle and flow meter / regulator used for this test.

FIG 11. Bubbles coming to surface in the coil tubing.

FIG 12. The gantry and winch for deploying the sensor in the well.

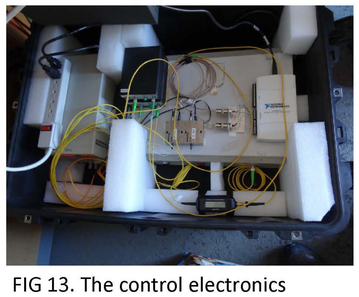

FIG 13. The control electronics package for the optical sensor.

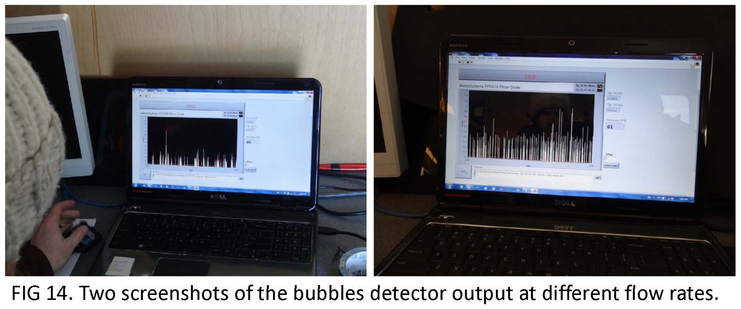

FIG 14. Two screenshots of the bubbles detector output at different flow rates. There are two sensors in the probe, one vertical and one horizontal. The two are shown in different colours, white and red on screen.