Seismic modelling and monitoring of carbon storage in a sandstone aquifer

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Abstract

Carbon Management Canada in association with CREWES have invested in a research project that investigates the feasibility of injecting and monitoring reduced amounts of CO_2 in a sandstone aquifer in Alberta. The shallow sandstone of Lower Paskapoo Formation at Priddis was considered as a possible target. In order to evaluate the monitoring viability, Gassmann Fluid Substitution and 3D seismic modeling were undertaken. Synthetic seismograms were generated to assess changes given the injection of CO_2 in Lower Paskapoo sandstone.

3D Seismic Modelling

• Generation of a 3D geological model that reproduces a detailed scenario of the injection zone. The tops of interest are Lower Paskapoo (LP), Edmonton (E) and a selected layer called Seal (Figure1).

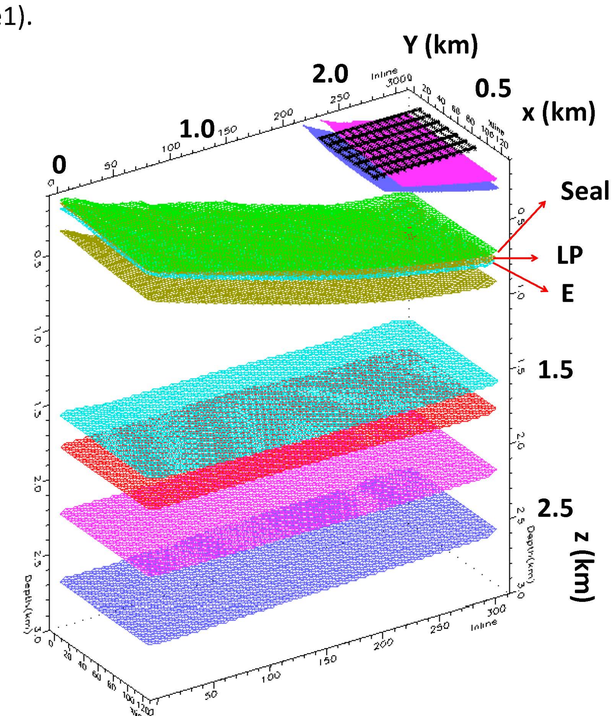

Figure 1: Geological model with the survey location. Position of Seal, LP and E.

• Design of the seismic survey appropriate to image the Paskapoo Formation and the plume.

• Estimation of the CO_2 plume, size and shape, using a volumetric method and cylindrical approximation. The reservoir was considered to have 50% CO_2 saturation.

• The plume was incorporated into the geological model, representing the post-injection scenario. The velocity and density values were obtained after applying Gassmann fluid substitution (Figure 2).

• Common shot wavefront ray-tracing was undertaken and data were processed and stacked.

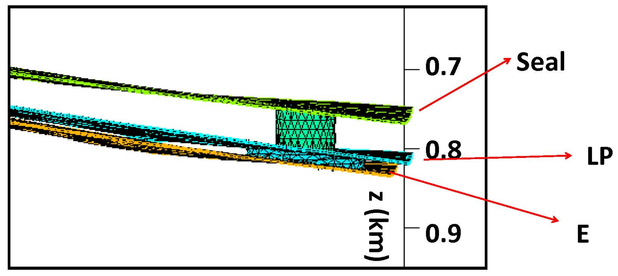

Figure 2: 3D view of the plume. The first cylinder is between Lower Paskapoo and Edmonton and the second between Seal and Lower Paskapoo.

Monitoring Results

• The presence of the CO_2 plume causes a decrease in density and P-wave velocity, producing: a reduction of the reflectivity values across the injection area and a time delay of the reservoir basal reflectors and horizons underneath it.

• Times for LP and E are approximated 380 ms and 392 ms respectively for baseline, with a time delay after injection of 1ms (Figure 3). Figure 4 shows a zoon in view of the injection zone of the baseline (0% CO_2 saturation) in comparison with 50% CO_2 saturation volume, presenting an evident reduction of the amplitude.

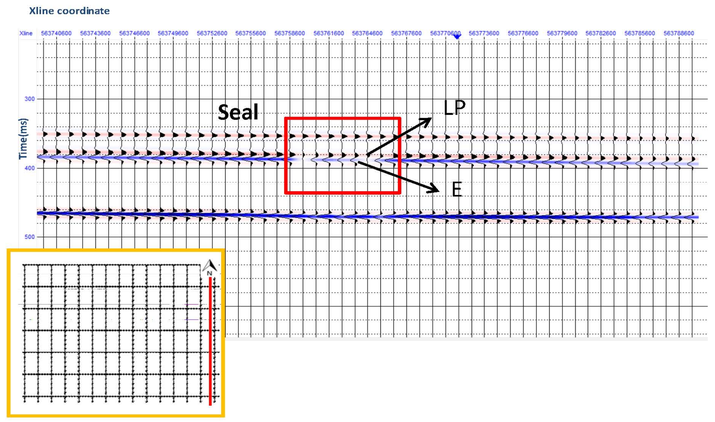

Figure 3: Crossline 140 showing the injection area in a red square, LP and E tops.

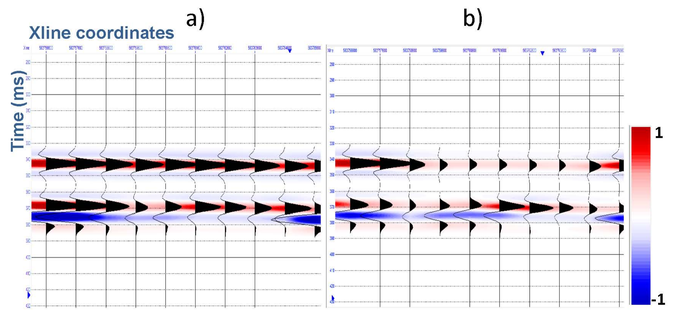

Figure 4: Zoon in of the injection zone.; a) 0% CO_2 saturation and b) 50% CO_2 saturation .

• There is a difference in amplitude and time recognizable in seismic by subtracting the post-injection volume to the baseline.

• Figure 5 is the difference between the monitor and baseline volumes from an inline and crossline perspective and Figure 6 shows the 3D perspective of the CO_2 plume.

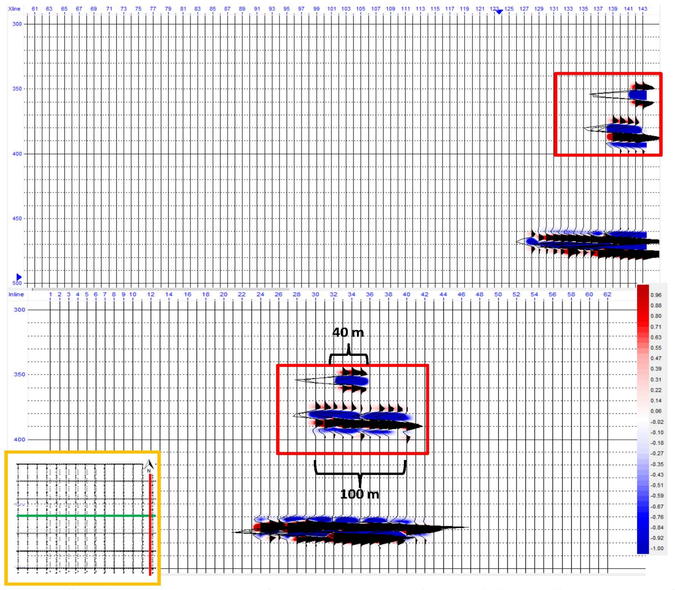

Figure 5: Inline (top) and crossline (bottom) view of the volume resulting from the difference between the baseline model and the CO_2 saturated. The area of injection is marked in a red square.

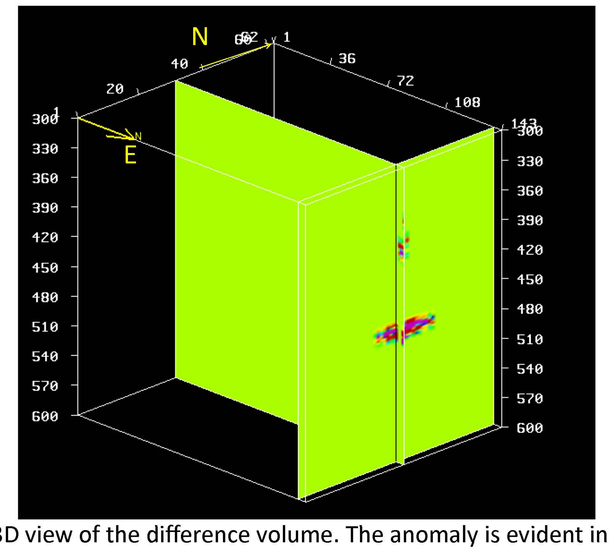

Figure 6: 3D view of the difference volume. The anomaly is evident in the area of injection.

Conclusions

•The presence of the CO_2 plume was detected in the seismic volume: measured time delay of approximated 1ms and amplitude reduction of approximated 10 %.

•Even these subtle changes cause considerable variations in the seismic response, and is observable on the difference between the monitor and baseline volumes.

•Lower Paskapoo Fm has suitable properties for a CO_2 storage site. The feasibility of monitoring small amounts of CO_2, even under small saturation changes, it has been proven by using fluid substitution and seismic modelling,

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