Geology, Seismic and Engineering Data of a Super-Deep Upper Devonian Carbonate Gas Reservoir Marsh Area, Hinton Alberta

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Summary

This presentation is an overview of the technical elements of the Marsh 14-33-052-26W5 well with an emphasis on integrating geological, geophysical and engineering data. The 14-33 well is a demonstration of the cross discipline efforts and collective knowledge-sharing required to overcome the obstacles and challenges in drilling a 6437m sour gas well. Following an acknowledgement of the people involved, the author will review the geology, seismic and engineering data of the Marsh area.

The Marsh area is a compelling example of the potential in deep, high temperature, low matrix permeability, carbonate gas targets.

Introduction

The Gregg Lake - Marsh property is located approximately 19 km northwest of Hinton, Alberta Canada near an environmentally sensitive area, the William A. Switzer Provincial Park. Two wells are currently producing sour gas from the Leduc Formation and a third well was required to adequately drain gas reserves within the reef complex.

The Marsh Leduc reef complex is 9 km long, 2.5 km wide elongated in a Northwest – Southeast direction (Figure 1). The reef is made up of a light grey, vuggy, sucrosic dolomite with porosity of 5 to 7% and permeability of 1 to 10mD. The lower Leduc reef is conformable with the underlying Cooking Lake Formation which consists of a dark brown dolomite. The top and lateral seal for these gas reservoirs is the Ireton shale.

The 07-07-53-26W5 well was originally drilled by Shell in 1990. The well was completed in 1998, and placed on production in January 2002 with an initial gas rate of 280 e3m3/d (10 mmcf/d). In 2000, a second well, Poco et al. Hinton 10-27-52-26W5M, was drilled and subsequently whip-stocked horizontally to a bottom hole location at 6-34-52-26W5, 1039 meters away (3408 feet). The 10-27 HZ 6-34 well was placed on production in January 2002 with an initial gas rate of 280 e3m3/d (10 mmcf/d).

The Marsh reef complex is similar to the Miette and Ancient Wall Frasnian reefs exposed in the Jasper National Park. Mountjoy provided a description of the Miette reef with isopach of the Cairn and Southesk Formation that are equivalent to the Marsh subsurface Cooking Lake, lower Leduc, Ireton and Nisku Formation. Another outcrop example at Burnt Timber in the Rockies shows a west dipping, massive porous dolomite at the reef crest with an easterly thinning reef margin. This outcrop can be used as a geological model for understanding the Marsh reef crest, reef margin and structure of the existing wells (Figure 2).

The Leduc reef complex has been mapped using a 3-D seismic survey shot prior to the creation of the Provincial Park. The prospect is a carbonate reef with sonic velocities over 5000m/sec. The top of the reef is mapped and marked by a strong positive (peak) reflector. Porosity within the reef can be 'readily' mapped where a contrast of velocity exists. A contrast of seismic velocity is created by the Duvernay cap rock (high velocity rock), the porous reef (lower velocity rock) and tight carbonate of the Cooking Lake and Beaverhill Lake below (high velocity rock). Within the reef complex where the Ireton shale is directly deposited on the reef, porosity can only be inferred but not mapped using seismic as no contrast of velocity exists between the Ireton (low velocity rock) and porous lower Leduc dolomite.

Using the structure of the reef top in conjunction with the isochronal map of the overlying shale, a reservoir isopach was constructed. This isopach explains why the reef is much thicker at 7-7 and much thinner at 10-27. When a seismic line is flattened using the Ireton shale, the thickness variations of the shale illustrates drastic thinning over the 7-7 well (a higher reef), whereas the shale is thicker at 10-27 (a smaller reef height) (Figure 2).

The 07-07-53-26W5 gas well was drilled on the crest of the reef and intersected 53 meter of porous dolomite with 40 meters (131 feet) of net gas pay. The ultimate raw sales reserves (EUR) for this well are 1,634 e6m3 (58 Bcf).

The 10-27 HZ 6-34 gas well was drilled at the margin of a lower Leduc reef and encountered 20 meters (60 feet) of porous dolomite (Figure 2). The ultimate raw sales reserves (EUR) for this well are 10 Bcf (282 e6m3).

Pressure surveys of the two producing wells indicate separate Leduc pools.

Permeability regain tests were conducted on several core plugs. One of the plug for example indicated porosity of 5% and air permeability of 1.6 mD at ambient conditions. Using the same core sample and restoring the core to reservoir pressure of 43,088 Kpa and temperature of 150C, the permeability to methane was reduced to 0.03mD. A permeability regain test performed on the same sample using the invert mud system used to drill the 14-33 well, further decreased the permeability by 36% to 0.013 mD. On average the permeability is ten fold less at reservoir conditions than at ambient conditions and the invert mud system can cause a reduction in permeability.

The third well location at Marsh was chosen based on a model developed from outcrop examples, reef geometry, seismic mapping and reservoir pressure data.

Based on the reconstruction of the geomorphology of the reef complex using geology and seismic, the 14-33 well location was expected to encounter 35 meters (115 feet) of gas pay with reserves in the range of 924 e6m3 (33Bcf) of raw gas.

The 14-33 was spud in October 2006 and reached TD in June 2007. Total measured depth of the 14-33 was 6437 m (5519m TVD). At TD the borehole had 1731m of horizontal displacement with a 63 degree inclination.

Conclusion

In the deep basin of Alberta, many smaller lower Leduc anomalies comparable to the Marsh seismic anomaly have not been drilled. A recent Leduc discovery at Tower Creek based on the work of the Burlington Kaybob Devonian Team, provides inspiration for more Leduc discoveries in the deep basin of Alberta.

The Canadian Gas Potential Committee author Greg Davidson (Geophysicist, Encana) estimates the remaining undiscovered reserves for the deep Basin Leduc play at 2.9Tcf with one large undiscovered pool of 1Tcf.

The author believes that exploration efforts focusing on lower Leduc seismic anomalies similar to Marsh may result in economically viable exploration discoveries.

The Marsh reservoir is a good example or model for deep low permeability high temperature carbonate gas exploration targets for the deep basin of Alberta and perhaps for other gas prone basins around the world.

References

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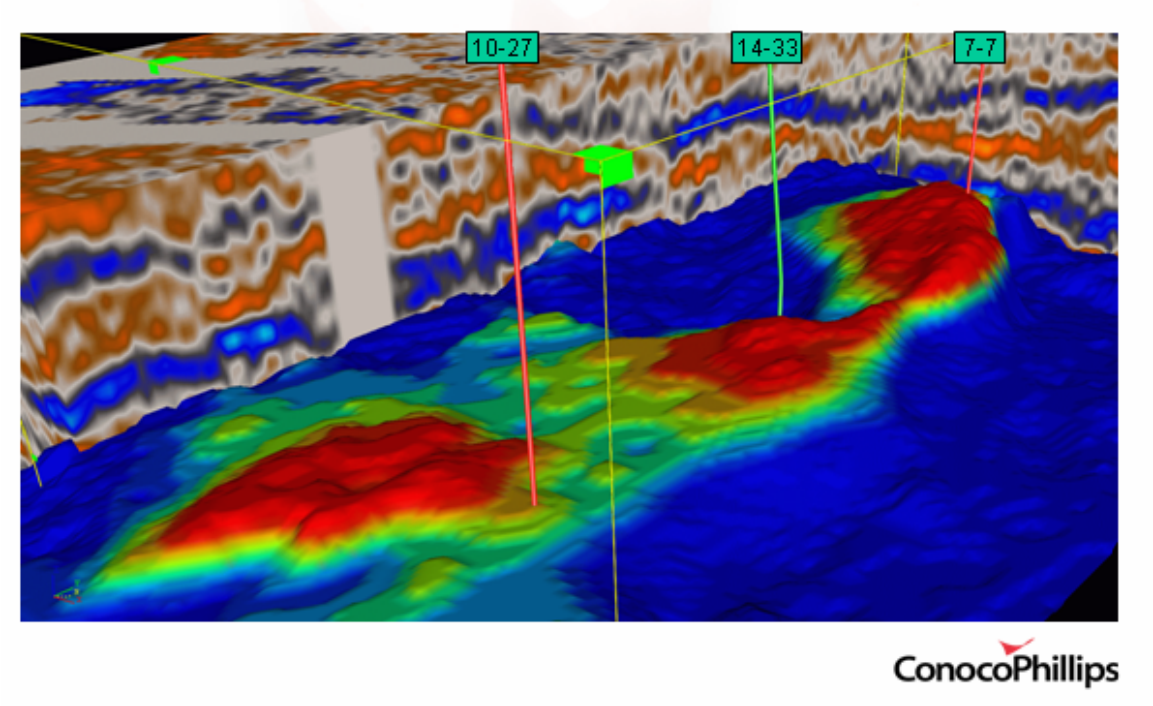

Figure 1: Seismic map of the Marsh Reef Complex with existing well locations.

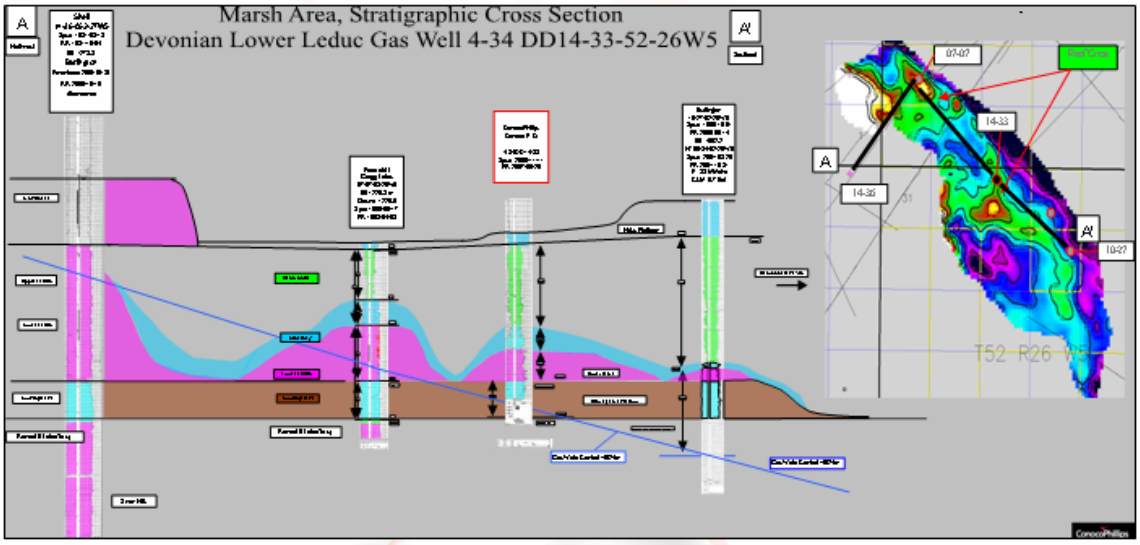

Figure 2: Stratigraphic cross section Illustrating Ireton and reef thickness variation over the 4 wells drilled in the Marsh area