Gas Storage Case Study: Southwestern Ontario

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Summary

Silurian aged reef structures underlie Southwestern Ontario in the Michigan Basin. These pinnacle reef formations were developed through cyclic sea level changes where each transgression enabled reef growth (Figure 1). Properly acquired and processed seismic data is capable of imaging larger growth cycles. Many of these reef structures produce hydrocarbons, others are used for seasonal gas storage. Using newly acquired seismic data and modern processing run streams, RPS was contracted to analyze a less than 3 km² single gas storage reef. The objective of the project was to identify drilling locations designed to increase both injection and withdrawal efficiency.

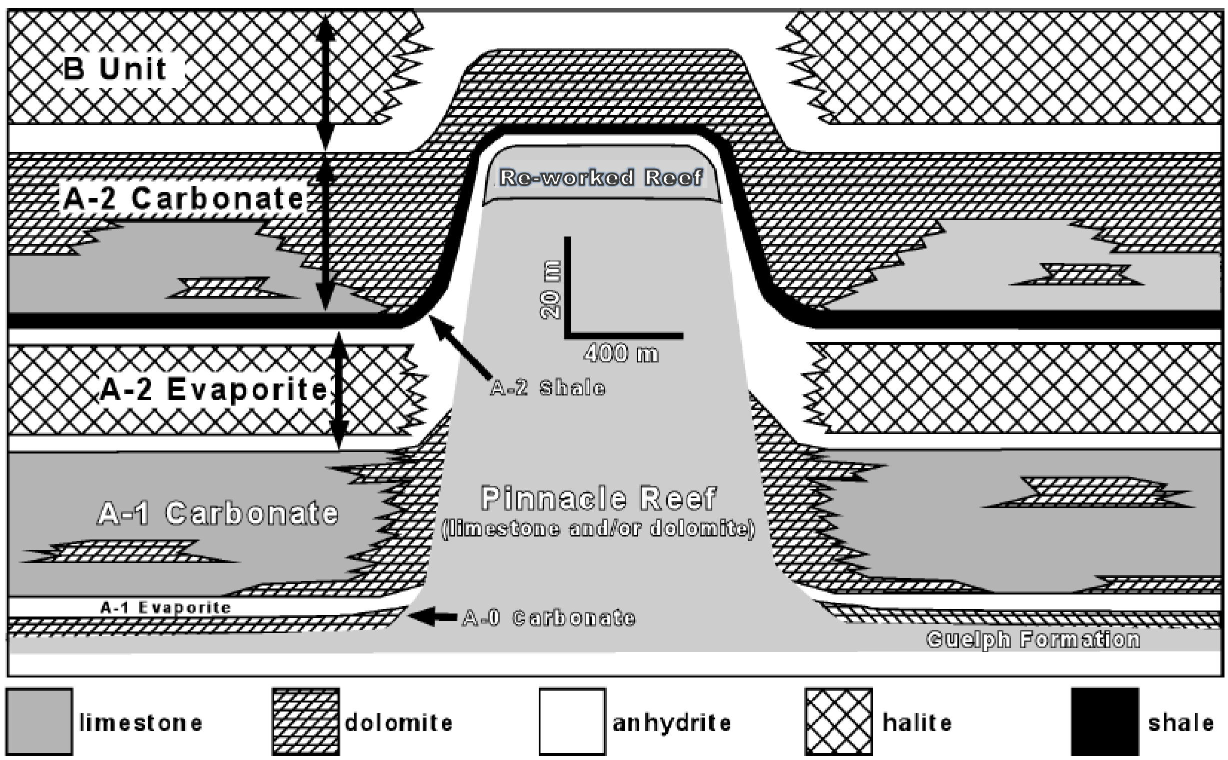

Figure 1: Schematic summary of Dolomitization Patterns in the Salina A-1 and A-2 Carbonate Units in the vicinity of pinnacle reefs in Sombra County (modified from Carter et al., 1991).

Prior to the project, more than 6 wells already penetrated the reef. Locations for all existing wells had been positioned prior to a 3D seismic survey being acquired and processed in 1989. Following a detailed analysis of past surveys in the area, it was determined that acquiring and processing a program with updated parameters could increase the probability of imaging the reef with sufficient resolution to optimize drilling targets. A new 3D survey was designed, acquired and processed in 2016-2017 by RPS Energy Canada. Several fit-for-purpose processing workflows were investigated to address noise, amplitude fidelity, and imaging challenges with the general pre-project assumption that post-stack inversion would be used as the final interpretive tool. Post-stack inversions were used to map zones of connected low impedance within the reef. Well log analysis, and local geological knowledge, suggest the zones of low impedance correlate to high porosity and permeability.

This case study demonstrates that well-established seismic processing technology and post-stack inversion methods with a focused 'fit-for-purpose' design philosophy can generate excellent results (value) in a 'mature area'. The analysis successfully identified new well locations that were drilled in 2018. Estimated deliverability of every new well exceeded that of any pre-existing well within the reef structure.

Workflow

Identifying a proper strategy to pick well locations for this project necessitated collaboration with all types of subsurface professionals: geologists, geophysicists, and engineers. Inter-disciplinary discussions led to workflows capable of optimally identifying connected zones of high porosity, ultimately increasing the deliverability of the pool.

When first approached for the project, work was done to better understand the geological setting and depositional environment. A search was completed to find all relevant wells both within the project area and further afield. It became evident that local well log data was limited as a result of the porous nature and operational use of the reef. Wells with sonic information were all located off-reef. Drilling fluid penetrates the existing gas storage facility, therefore the only logs available on-reef are those that do not require fluids to operate, such as Neutron and Density. Sonic logs, when needed, were estimated from boreholes located at some distance from the target reef.

The previous 3D seismic data was shot and processed in 1989 and therefore had sampling and imaging limitations (e.g. 3D migration) that made delineating the edges of the reef difficult. Due to these limitations, it was determined that a new seismic program, rather than reprocessing the existing 3D, would provide a more detailed image for the reef. A detailed analysis of historical seismic surveys allowed for optimization of the new program. The new 3D data was subsequently processed to minimize noise, maintain amplitude fidelity, and improve the interpretation of the reef terminations. The data was processed with the knowledge that an inversion would ultimately be used to identify well locations.

Inversion is known to highlight geological boundaries corresponding to impedance contrasts. Uncertainties related to the complete absence of shear wave logging in the entire project area, and the absence of any P wave logs within the economically important part of the reef, suggested that inversion should be limited to post stack P impedance. Inversion was conducted in time domain and depth converted using well control in GoCad software. Depth domain geobody analysis was completed on the impedance volume to determine the extent and thickness of low impedance zones. Based on operator information and known storage volumes of this reef, it was ascertained that zones of low impedance corresponded with wells that had high deliverability. Based on this information, new well locations were chosen in areas where the impedance geobodies were thickest, best connected, and had the lowest impedance values.

Results

Based on the fit-for-purpose approach several well locations were chosen with the goal of improving the deliverability of the existing pool. The locations were then high-graded based on surface limitations and proximity to existing pipelines. Upon completion of the drilling program, it was determined that all the new wells drilled on the impedance geobodies exceeded the deliverability of the existing wells.

Through the integration of geological parameters obtained from the operator and geophysical technologies applied by RPS, zones of high porosity and deliverability were successfully identified. The project demonstrated that well established technologies, employed in a consciously ‘fit for purpose’ fashion by a focused multi-disciplinary team can generate high value outcomes at modest effort (i.e. cost).

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