# Porosity-Thickness Prediction by Application of AVO/LMR Analysis to Seismic Data: A Case Study from a Clastic Lower Cretaceous Gas Reservoir at Crossfield, Southern Alberta

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This talk discusses a case study of successful seismic AVO/LMR interpretation including results from 20 well locations based on the technique. We use this example also to outline a suggested workflow for practical AVO/LMR application.

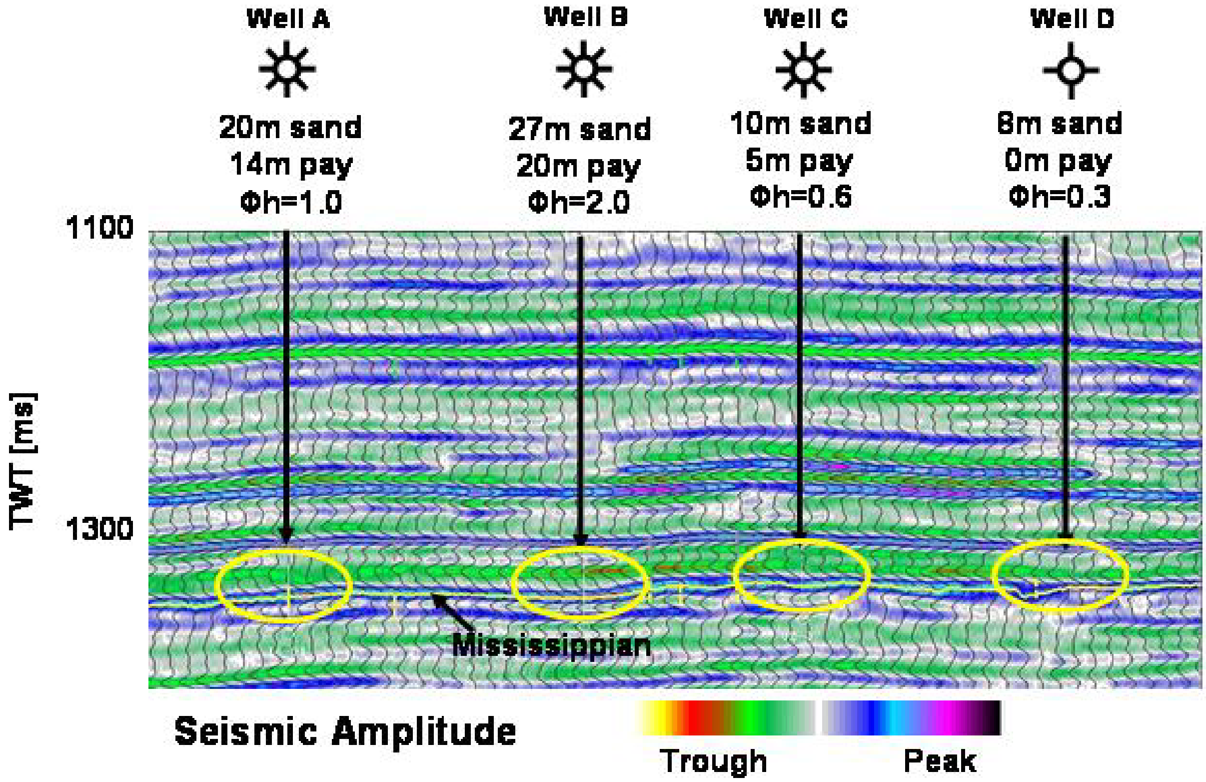
The Basal Quartz (BQ) gas pools in the Crossfield area of Southern Alberta have been on production for over 30 years. At the beginning of our study, production history data from the 39 existing BQ producers indicated additional reserves potential, prompting a full geological and geophysical re-evaluation of the property.

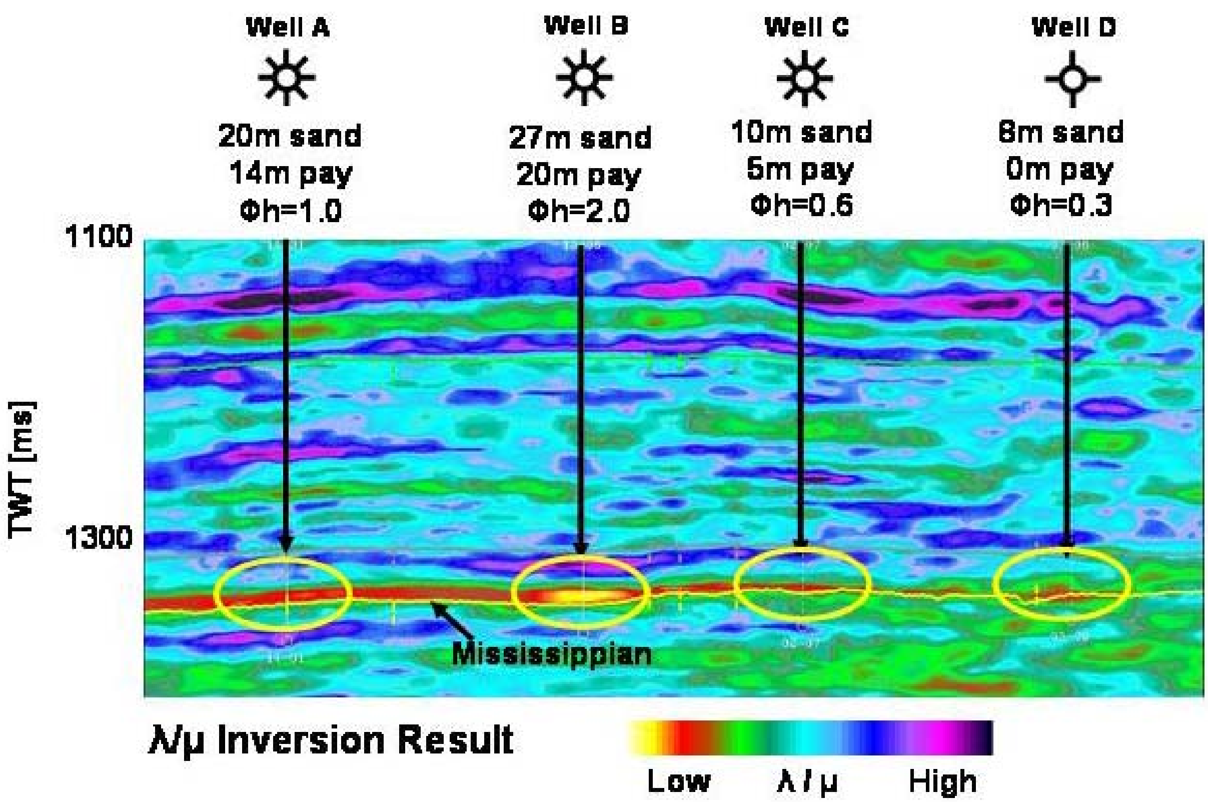
The productive Lower Cretaceous Basal Quartz reservoir was deposited within a major valley trend at the unconformity between the Paleozoic and the Cretaceous that can be mapped using seismic data. The reservoir rock consists of sandstones that were deposited in a complex succession of fluvial channels with a wide variety of thicknesses, grain sizes and mineralogy. At an average depth of 2100m, variable effects of compaction and diagenesis (calcite and/or quartz cementation) further complicate the reservoir. Consequently, reservoir quality within the trend is extremely inhomogeneous. Typical reservoir porosities average 9% but the porosity-permeability relationship is highly variable. Net pay thicknesses for economically successful wells are between 5m and 20m.

Historically, paleo-valley maps together with seismic amplitude anomalies had been used with reasonable success to select well locations. A comprehensive review of the amplitude data at all existing well locations revealed only a very weak correlation between seismic amplitude/character and the presence of commercial thicknesses of reservoir quality rock. The cause for this poor correlation is twofold. First, the reservoir itself shows extreme variation of thickness, quality (correlated to impedance) and number of channels (tuning). Second, the lithology of the Mississippian subcrop underlying the BQ reservoir changes in the area of interest from high impedance Pekisko carbonates to low impedance Shunda shales.

For a successful new round of drilling, including both infill and higher risk exploratory wells along the flanks of the BQ valley trend, a better method to identify reservoir sweet spots was needed. Synthetic seismic gathers calculated from an existing BQ well with Dipole sonic log information showed an excellent (type 3) Amplitude Versus Offset (AVO) signature. Lame's parameter-density products (LambdaRho and MuRho, LMR) were calculated from the log data and analyzed in crossplot space proving a clear separation of the reservoir intervals from all other typical lithologies encountered in the well. A feasibility test inverting a seismic line through a number of existing wells confirmed the sensitivity of the LMR response to reservoir quality and net pay thickness.

Subsequently, more than 20 new BQ wells were located based on LMR inversion results using both 2D and 3D seismic datasets. This drilling program had an economic success rate of 75%. The sub-economic wells drilled as part of the program encountered BQ reservoir with reasonable porosity-thickness but with inadequate permeability. Detailed crossplot analysis of the seismic inversion data using all new well results reveals an excellent correlation of LMR response and porosity thickness found in the BQ. This correlation demonstrates that, under the right circumstances and with careful analysis and calibration, we can approach a quantitative prediction of porosity thickness/net pay from surface seismic data.




Example of 4 wells located using LMR interpretation. Top example shows a migrated seismic amplitude section. Observe the absence of a consistent seismic amplitude or character anomaly, particularly for the well locations on the flanks and outside the main valley cut (wells C and D). The bottom example shows the same wells on the corresponding Lambda Mu Ratio section. This attribute shows distinct anomalies whose intensity correlates with the reservoir thickness encountered in the wells.

From our experience with this project we suggest a workflow for practical LMR interpretation as follows:

1. Define a clear objective for the LMR study (e.g. lithology prediction, porosity detection, fluid prediction etc.)

2. Calculate synthetic seismic gathers using Dipole sonic logs from relevant wells (if available) to determine the type of AVO response to expect, and to develop a feeling for how diagnostic the AVO signal is regarding your objective.

3. Analyze the log data in LMR crossplot space to see how your target zones separate from the background, how sensitive the LMR parameters are to the rock properties and if there are other lithologies present that potentially can be mistaken for your target.

4. If you have seismic data across relevant existing wells run an AVO/ LMR inversion as a ground truth test for the method. Closely quality control this processing/inversion flow, understand the results with respect to the synthetic seismic gathers from step 2 and optimize your processing/inversion parameters accordingly.

5. Apply the optimized inversion flow consistently to your data with continuing close quality control including analysis of the LMR inversion results in crossplot space.

7. Use the crossplot space to support your final interpretation of the LMR volumes.

8. After a well is drilled do a look back study to evaluate the performance of the technique with regards to the objective defined in step 1. Consider convincing your engineer to run a dipole sonic log in the well for this purpose.

This case study shows an example for LMR application in an area with a “rich” set of data which is a prerequisite for many of the above steps (i.e. availability of well ties, dipole sonic logs etc.). In the absence of similar well information LMR inversion can still provide valuable information to the explorationist, however the expectations as to the scope and accuracy of the results have to be adjusted to stay realistic.