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# Comparison of Various Seismic Inversion Methods – A Lower Manville Case Study

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## Summary

Seismic Inversion has been critical part of the hydrocarbon exploration and development workflow. Since its early implementation in late 1970's seismic inversion has undergone multiple reinventions to take advantage of new formulation and ever-enhancing computer capabilities. Inversion is now becoming everyday required tools for a seismic interpreter. This paper presents the application and comparison of various methods using a single case study of Mannville incised valley using deterministic, elastic, stochastic, Bayesian, HIT Cube, and Neural Network inversions.


## Theory

Seismic Inversion first introduced by Roy Lindseth 1979, played one of the key roles in quantitative seismology. The stratigraphic and lithological information could be quantified using various inversion methods developed over the years.

Acoustic Impedance Inversion led to the development of Elastic Impedance Inversion (Connolly 1999) that was later further modified with the concept of Extended Elastic Impedance. All these methods were based on error minimization between the original seismic and the synthetics generated from the inverted seismic property such as impedance. A major limitation of deterministic inversion was its bandlimited nature where a-priori information is needed outside the seismic bandwidth.

In 1990s stochastic inversion methods were introduced. Using the geostatistical methods of kriging and covariance, one can simulate a distribution of high frequency models where reflectivity of each model yields similar reflectivity as observed in the seismic data. By applying stochastic simulation, the range of the inversion results could be obtained where the average result from all possible solutions is still deterministic. Such stochastic inversion methods assumed that the error close to the wells is always lower than the seismic traces far away from a well location.

In 2000's there were further advancement not only in the deterministic and stochastic methods but also in geological modeling. It has been observed that if we use geological and stratigraphic models based on seismic interpretation and relative inversion, we could achieve more realistic inversion solutions. Such inversion solutions using pseudo-well modelling is the basis of HIT Cube inversion. Most recent probabilistic methods include geological facies at an early stage either through pseudo-well synthetic modeling or through stochastic facies models.

Throughout the history of inversion advancements there have been an outlier solution of neural network-based inversion where no model is applied, and the results are advanced through comparisons of inversion solutions and their relationship to the real data. Neural networks inversion methods are further enhanced in 2010's through extreme computer power and deep learning. In many cases the neural networks or deep learning inversion relies on another inversion method that could take away the wavelet affect from the seismic such as colored inversion.

## Case Study

Blackfoot 3D dataset was acquired by University of Calgary CREWES consortium. The multi-component dataset has been a key test dataset for the development of many software and algorithms and has been presented at various conferences to show the efficacy of algorithms to detect incised valley and hydrocarbon bearing high porosity channel systems hiding within many lithic channels and shales. Some of the excellent work published by Pendrel 2001 clearly describe the application of deterministic inversion method to the Blackfoot 3D dataset.

Our work starts with the processing and conditioning of the gathers. For the simplicity of comparison, we will only deal with the P-wave reflection data. The input for all the processes is the same seismic gathers although some of the inversion methods will use only angle stacks.

The tests are carried out where the inversion is not dependent upon other inversion methods and we also tested where deterministic inversion is used as an additional attribute. The results are analyzed against blind wells that are not used in the building the background or training the neural networks.

## Conclusions

This study further confirms some of the concepts and limitations of band-limited seismic data to predict log properties but also shed light to the future of the seismic inversion methods where many of the seismic inversion methods are going to be used in tandem to each other rather than applied in isolation.

The quantitative interpretation has progressed through many decades of advancements and has been reaching a mature stage where the answers to the rock property prediction lies in the integration of advanced gather conditioning, inversion methods, geological and statistical models and neural networks.

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