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Deliniation of a Thin Sand Reservoir using Geostatistical AVO Inversion

Jawwad Ahmad*
Fugro-Jason Inc., Calgary AB Canada
jahmad@fugro-jason.com

and

Cheran Mangat and John Pendrel
Fugro-Jason Inc., Calgary AB, Canada

Summary

Thin reservoirs are often challenging to explore because of the limited resolution of seismic data. Geostatistical AVO Inversion incorporates all available subsurface information in a Bayesian engine and provides output simulations of elastic reservoir properties as well as their probabilities. In this way, uncertainty information is also captured and can be used in intelligent manner.

The Geostatistical AVO Inversion algorithm used in this study combined ideas from traditional Geostatistics with Simultaneous AVO Inversion and Bayesian analysis. A Markov Chain Monte Carlo(MCMC) engine was used to generate the actual simulations from the joint probability density functions resulting from the inversion. The key inputs are partial angle stacks and their associated wavelets. Prior statistical information corresponding to the elastic properties to be estimated was provided by property histograms derived from logs (1^{st} order statistics) and by Variograms (2^{nd} order statistics). The latter are estimated in the vertical direction from logs and in the lateral directions from previous deterministic inversions and analogues. They can be facies-dependent. All of the inputs are then simultaneously inverted for the elastic properties: P-Impedance, S-Impedance or Vp/Vs, Density and lithofacies.

Thin Cadotte Sandstones in the Western Canadian Sedimentary basin were successfully imaged and mapped using this technique. Four key lithofacies and their associated first and second order statistics were defined from the available wells. The statistics along with a set of partial angle stacks were input to the Geostatistical AVO process. The final results of the inversion were probability volumes for the lithofacies, and the elastic reservoir properties, P-impedance, S-impedance and Vp/Vs. Each lithofacies was found to occupy a unique and distinct region in elastic parameter cross-plot space. The elastic properties for Geostatistical AVO Inversion were determined to exhibit slightly higher resolution compared to a conventional deterministic AVO inversion. The matches with the well logs were also good even though the inversion was run in a *blind-to-the-wells* mode. A set of 10 separate realizations of the Geostatistical AVO Inversion was computed. The lithofacies probabilities determined from this set of realizations provided uncertainty information. The initial inversion results were subsequently used as co-simulators in a further simulation for effective porosity. Each output realization from the first set of AVO Inversions was used in turn, to produce a set of porosity realizations. This helped in calculating reserves, running economics and ranking different prospects quantitatively. The result was more reliable in picking drilling locations.