Proposed GSI geostatistical workflow for improved acoustic impedance estimations: A successful case study for the Brazilian pre-salt reservoirs, Santos Basin.

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Abstract

The continuous development of geostatistical seismic inversion methodologies allows for more reliable estimates of reservoir properties, such as acoustic impedance, porosity, density, and velocity, to be derived from the combination of seismic and well data. Commercial seismic inversion applications try to keep up with this continuous development, but many off-the-shelf solutions do not incorporate all the innovations, or the latest geostatistical inversion approach, which implies in a limitation of accuracy for improved property estimation processes.

Geostatistical inversion methodologies often heavily rely on geostatistical simulation. The running process involves the generation of multiple realizations of the subsurface model, each one statistically satisfying the defined constraints led by the data and the geological information. The obtained realizations are then useful for realistic estimation of subsurface properties. However, the accuracy of the property estimation strongly depends on the quality of the stochastic simulation, inside the geostatistical inversion frontier.

Fortunately, commercial modeling/simulation software solutions are robust. Through them it is possible to perform geostatistical analysis and simulation with applications such as Sequential Gaussian Simulation (SGS) with co-kriging, Bayesian simulation, and other methods, as well as 3D variographic analysis, generating structural and stratigraphic models. These methods are useful for studies alternative geostatistical impedance realizations, besides the standard solutions available in dedicated inversion software.

Among the methodologies used for inversion, the acoustic geological seismic inversion (GSI) methodology combined with SGS is a simple implementation in commercial geological modeling software. The implementation of GSI with SGS in commercial software allows for the integration of geostatistical simulation, structural modeling, and rock physics concepts, leading to more accurate results, which we intend to demonstrate through this work.

To design the workflow for geostatistical inversion using GSI, the concepts of geological modeling and geostatistical simulation must be applied. The workflow involves structural modeling, geostatistical simulation, and seismic inversion, all of them in the same level of importance. The structural model defines the geometry of the subsurface layers and the intrinsically property distribution. The geostatistical simulation pushes the multiple realizations generation of the subsurface model, each one satisfying the statistical constraints, which were defined by the data and the analogous geological information. Finally, the seismic inversion solves the subsurface properties dilemma´s estimation by the comparison of the modeled synthetic seismic data with the observed seismic data, minimizing the related differences. Therefore, here we present an approach for stochastic acoustic impedance inversion, using a dataset of the Tupi Field, combining geostatistical modeling and seismic inversion technique. The goal of this study is to analyze the associated uncertainties of the seismic inversion process, assessing improvements regarding resolution of geostatistical the resulting impedance model. Our results demonstrate that the obtained acoustic impedance model presents great well logs´ correlations, displaying a low residual aspect between the real and the synthetic seismic data. This suggests that the combined approach used in this study can effectively increase the resolution of the resulting model while minimizing the associated uncertainties with the seismic inversion process.