AAPG Datapages/Search and Discovery Article #90319 ©2018 GEO 2018 13th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 5-8, 2018

Global N-Dimensional Petro-Elastic Optimization for Closed-Loop Simulation to Seismic Calibration

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ABSTRACT

Proper calibration of the petro-elastic model (PEM) is a necessity for simulation-to-seismic processes so that continuity of the simulator response with seismic inversion is maintained. The dry rock properties in the PEM must be computed in the absence of mechanical rock tests. A global optimization technique is used to evaluate a multidimensional pseudo-objective function with three-dimensional (3D) geocellular design variables to constrain the PEM and improve the continuity of the reservoir simulation model with seismic inversion results. Global N-Dimensional design optimization techniques involve the determination of an optimum solution for a multidimensional pseudo-objective function comprised of design variable, which are characterized as multidimensional. This study investigates the use a modified particle swamp optimization (PSO) method with external penalty function (EPF) in addition to available well logs and reservoir description to determine dry rock data in the PEM. The PSO with EPF method is robust, enabling sensitivity analysis in addition to the derivation of an optimum solution in the prescribed parameter space. Global multidimensional optimization is used in a field case involving ill-posed elastic property characterization for a PEM in a reservoir simulator. This paper shows how the metaheuristic PSO can be constrained with EPF for multidimensional design variables in a multidimensional pseudo-objective function to derive dry rock properties in the absence of saturated rock properties. While local disparities exist, they are juxtaposed against classical modifications applied to reservoir simulation models that render them to be deficient of geologic context. The techniques employed in this study demonstrate a novel and robust application of multidimensional optimization of a constrained metaheuristic technique to closed-loop simulation-to-seismic integration. The work highlights an alternate method to derive rock property models without well logs and cores by honoring the physical description of the system and the seismic inversion.