Full-Field 4D Image-Modelling to Optimize a Closed-Loop Seismic Reservoir Monitoring Work-Flow

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Abstract

Objectives

Redefine the conventional closed-loop seismic reservoir monitoring workflow to include Full-Field 4D Image-Modeling, and illustrate with a case history

Procedures

Full-field 4D image-modeling incorporates the geologic, reservoir simulation, and reservoir geomechanical models into an integrated dynamic integrated earth model (DIEM) to surface. From which 3D grids of petro-elastic parameters for a range of reservoir simulations are derived via the rock-physics model for input into finite-difference forward-modeling and imaging. By including 3D wave propagation, acquisition geometry, overburden illumination, near surface effects, and calibrated noise the seismically measurable 4D-response predicted via full-field 4D image-modeling is more robust, and higher fidelity than is achievable via more traditional methods

Case History

The Chimera geologic, reservoir, and geomechanical models are integrated into a DIEM. The reservoir model has a sand porosity of up to 0.25 and permeability of up to 200 mD with light oil, an initial gas cap supported by an aquifer from the bottom, accumulated within a structural trap segmented by normal faults. Production scenarios are simulated from 2014. The 4D-response is forward modeled with full-field 4D image-modeling and a traditional workflow and compared.

Conclusions

All aspects of the 4D-response: time-shifts, amplitude changes, AVO changes, compaction, and subsidence are modeled into future time for a range of production scenarios from the Chimera DIEM.

Noise free forward-modeling provides a qualitative understanding of the nature, magnitude, and distribution of the 4D-response, and ties reservoir changes to the corresponding seismically measurable 4D-response.

With the inclusion of calibrated noise the forward-modeling models the seismically measurable 4D-response, from which the optimal measurement method and acquisition design can be determined, to record the seismically measurable 4D-response at the required time-steps for proactive reservoir monitoring.

Full-Field 4D Image-Modeling is necessary to fully understand the complexities of reservoir property changes over time, to assess whether those changes are seismically detectable, and to make informed decisions on the 4D time-lapse measurement method, design, and reservoir monitoring strategy