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Streamline-Based Time-Lapse-Seismic-Data Integration Incorporating Pressure and Saturation Effects

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Summary

We present an efficient history-matching technique that simultaneously integrates 4D repeat seismic surveys with well-production data. This approach is particularly well-suited for the calibration of the reservoir properties of high-resolution geologic models because the seismic data are areally dense but sparse in time, whereas the production data are finely sampled in time but spatially averaged. The joint history matching is performed by use of streamline-based sensitivities derived from either finite-difference or streamline-based flow simulation. For the most part, earlier approaches have focused on the role of saturation changes, but the effects of pressure have largely been ignored. Here, we present a streamline-based semianalytic approach for computing model-parameter sensitivities, accounting for both pressure and saturation effects. The novelty of the method lies in the semianalytic sensitivity computations, making it computationally efficient for high-resolution geologic models. The approach is implemented by use of a finite-difference simulator incorporating the detailed physics. Its efficacy is demonstrated by use of both synthetic and field applications. For both the synthetic and the field cases, the advantages of incorporating the time-lapse variations are clear, seen through the improved estimation of the permeability distribution, the pressure profile, the evolution of the fluid saturation, and the swept volumes.

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