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Geologically Consistent History Matching of SAGD Process Using Probability Perturbation Method

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Summary

The overall objective of reservoir modeling is to reduce the uncertainty in the production forecasts by utilizing all available data to construct a calibrated reservoir model. Geological heterogeneities have a fundamental impact on the growth of the steam chamber and the performance of the SAGD. The objective of this work is to incorporate the geological heterogeneities into the history matching process using probability perturbation method (PPM) to preserve the geological consistency of the reservoir model.

Theory

PPM is a geological data integration framework which employs multiple point geostatistics (MPS) algorithm. The heart of this method is to systematically perturb the underlying probabilities used to generate the reservoir facies. PPM generally consists of two loops; an outer loop which is responsible for randomly generating a global configuration of the facies, and an inner loop which systematically perturbs the generated facies to match the dynamic data. The combination of these two iterations creates a set of realizations that preserve the geological information.

Results, Observations, Conclusions

In this paper, a training image is built based on a 3D outcrop description of a meandering channelized reservoir that is analogous to some of the Canadian heavy-oil fields. All other available data including reservoir properties at well locations, seismic volumes and production data are also incorporated into the PPM framework for this history matching process. The reservoir model is characterized by three facies: clean sand, medium grained sandstone and silt, which have different porosity, horizontal permeability and vertical permeability. The SAGD performance is a function of steam chamber development, which depends on the level of heterogeneity in the reservoir. The results show that the heterogeneity distribution has a large impact on the fluid flow at different stages of production. Small scale heterogeneities influence the steam chamber development and fluid flow near the wellbore area, while large scale heterogeneities highly impact the oil recovery during the whole recovery process. The results show that such complexities can be well preserved during the history matching process using PPM by generating the geological patterns depicted in the training image. PPM is shown to be an efficient approach for the history matching in presence of complex reservoir geology.

Novel/Additive Information

In this paper, we have developed a novel multi-region PPM method that for the first time has been applied to history matching of the SAGD process. In multi-region perturbation, different geology perturbation is applied to different parts of the reservoir. Therefore, the regions with matched production are remained unchanged while the regions with unmatched production are perturbed. This is obtained without creating discontinuities in the geological properties of the model.