Integration of Data-Driven Models for Characterizing Shale Barrier Configuration in 3D Heterogeneous Reservoirs for SAGD Operations

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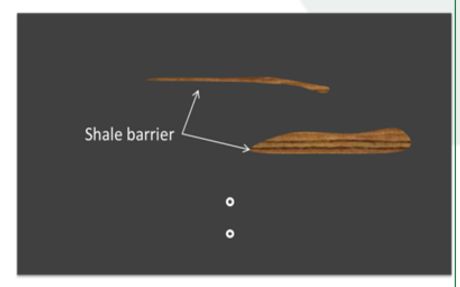
BACKGROUND AND OBJECTVIVES

Shale barriers may act as flow barriers with adverse impacts on the steam chamber development in steam-Assisted Gravity Drainage (SAGD) operations. Efficient parameterization and inference of such heterogeneities in 3D models from production data remain challenging.

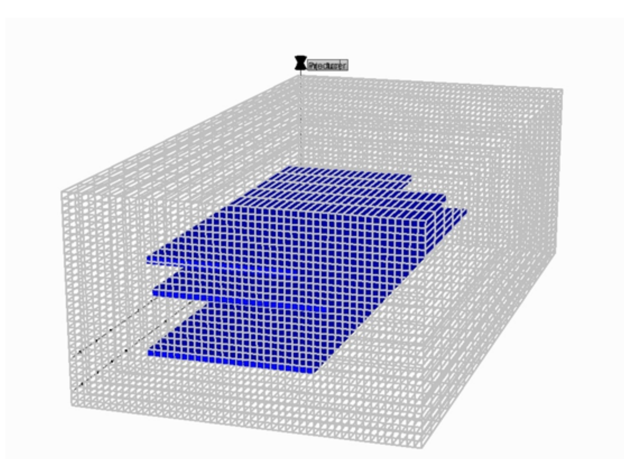
The objective of this work is to develop a practical workflow for inference of shale configurations in 3D SAGD reservoirs from production profiles using data-driven modeling techniques.

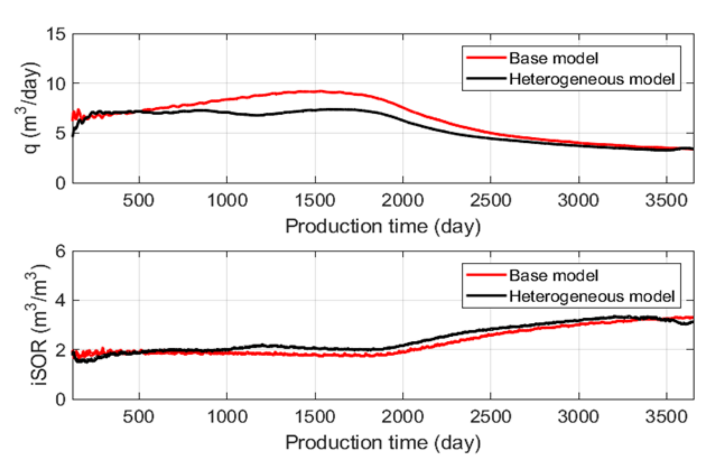


METHOD

Construction of 3D SAGD Model:

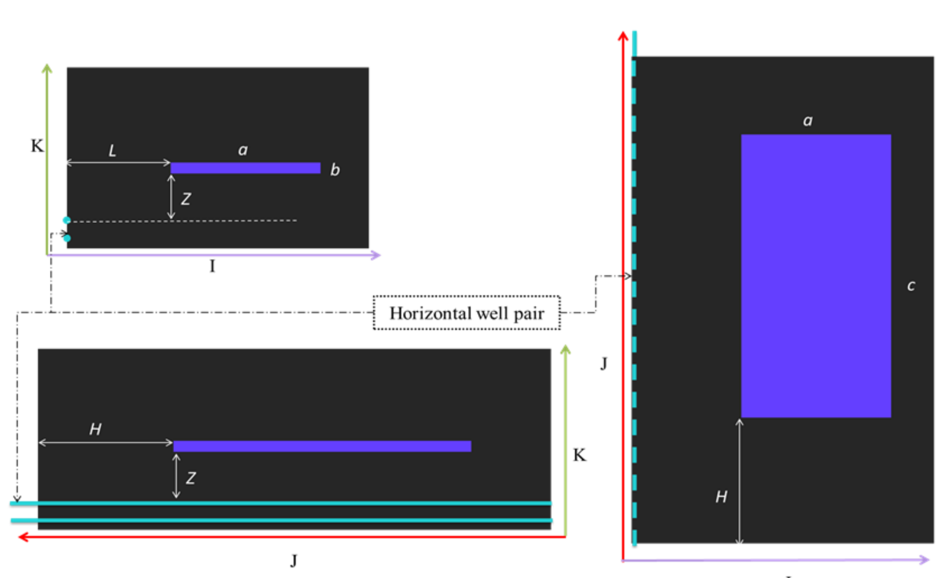
Typical Athabasca oil sands properties and operational parameters are used to construct synthetic 3D SAGD models. Profiles of oil rate (q) and instantaneous steam-oil-ratio ($iSOR$) are recorded by subjecting the generated models to numerical simulation (CMG).





Formulation of Output Parameters from 3D SAGD Models:

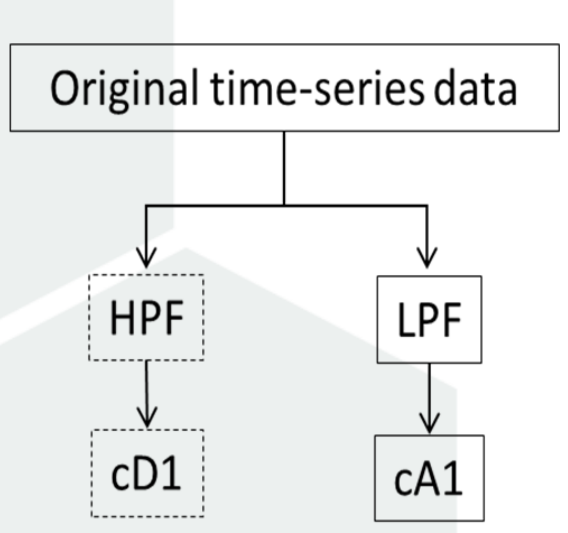
A particular shale barrier in 3D reservoir can be defined by its location (Z, L, and H) and geometry (a, b, and c) parameters.

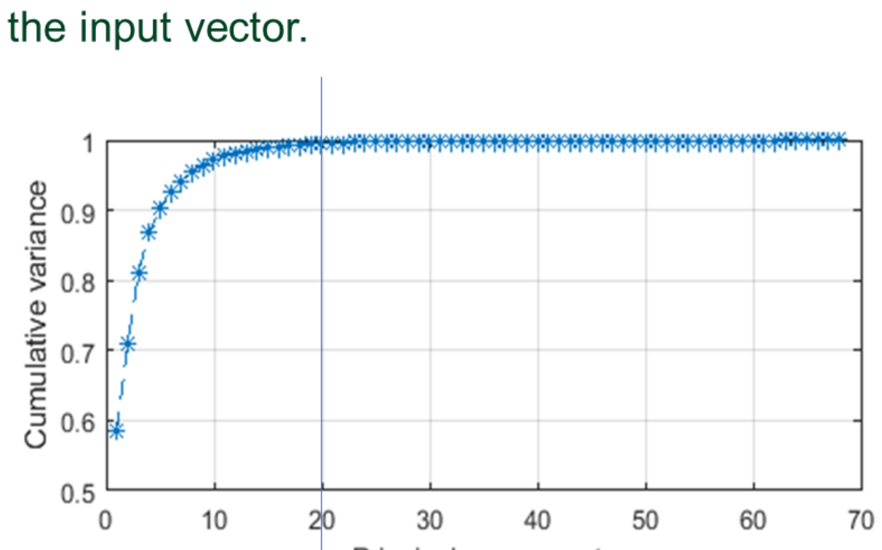


Through a detailed sensitivity analysis, three variables are formulated as output parameters to represent a certain shale barrier, including Z, L, and $V = a \times c$.

Input Feature Extraction from Production Time-series Data:

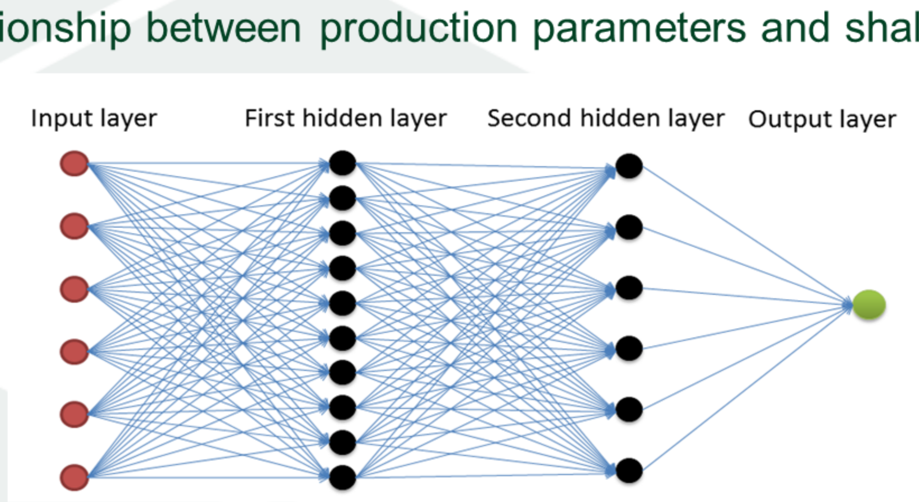
Discrete wavelet transform (DWT) is employed to extract input features from production time-series data Δq and $\Delta iSOR$. Principal component analysis (PCA) is applied to reduce the redundancy and dimensionality of the input vector.





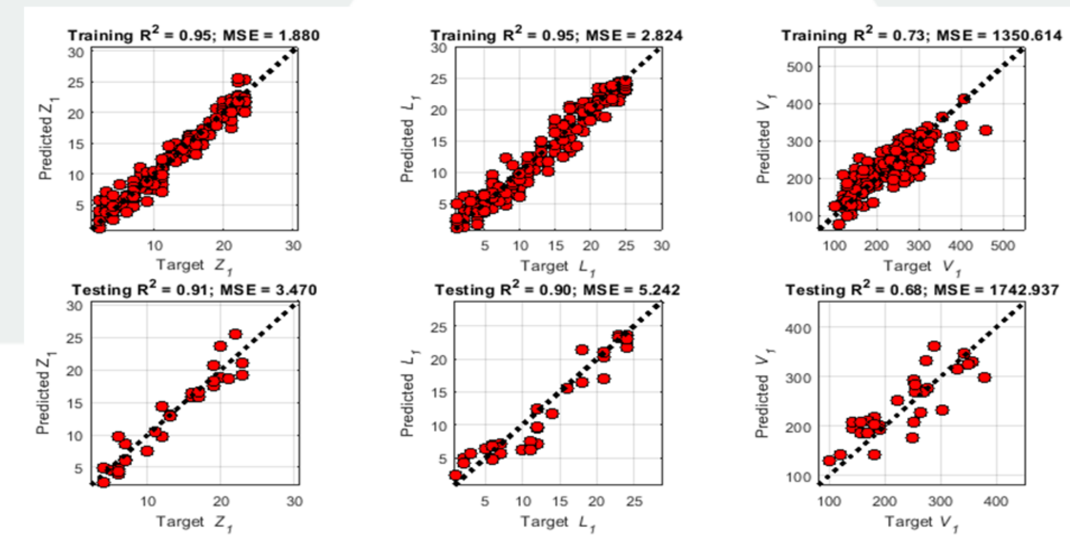
Construction of Data-driven Models:

Artificial neural network (ANN) is employed to construct a series of data-driven models to infer the relationship between production parameters and shale variables.



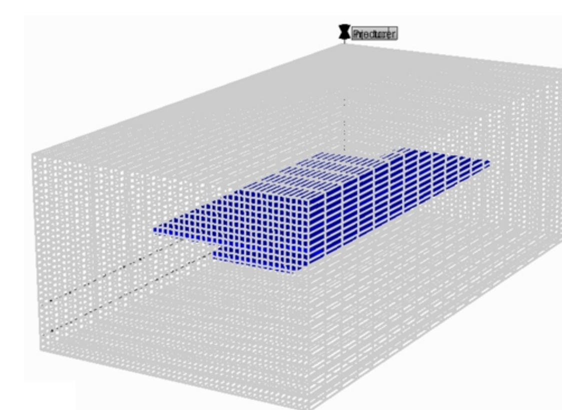
RESULTS

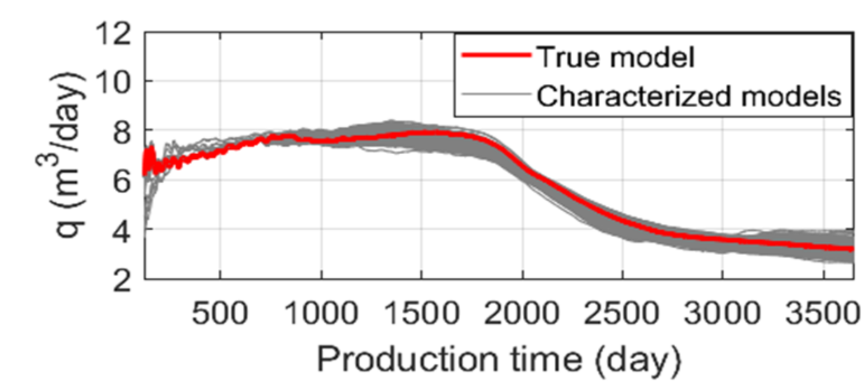
Estimation of Shale Parameters:



Performance of Characterization:

The characterization workflow developed in this work is examined using several examples.





The predicted values are in good agreement with the true values in all cases. The estimated shale parameters are subsequently used to generate an ensemble of realizations. The production profiles of the ensemble of characterized models are compared with that of the true model. It is easy to observe that the production profiles of the characterized models are consistent with the true case.

CONCLUSIONS AND FUTURE DIRECTIONS

Conclusions:

- Novel input and output parameterization schemes are proposed.
- A large training dataset is assembled using synthetic 3D SAGD models.
- Data-driven models are successfully developed using ANN to estimate unknown shale parameters.
- The final outcome is a set of 3D heterogeneous models that are consistent with the actual SAGD production histories.

Future Directions:

- Other artificial intelligence algorithms will be tested to improve the results.
- The parameterization scheme and data-driven modeling workflows will be extended to model other types of reservoir heterogeneities such as lean zones.

FES PROJECT OVERVIEW

T07-C02:

Development of novel reservoir management strategies and advanced optimization algorithms for thermal and thermal-solvent based recovery processes using fundamentals, scaled models, and machine learning.

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