Stochastic Modeling Workflow to Generate Representative Geologic Variability in Training Dataset for SMART Initiative

Priya Ravi Ganesh[1,2]; Brigitte Petras[1,2]; Jared Schuetter[1,2]

[1]National Energy Technology Laboratory, 626 Cochran Mill Road, Pittsburgh, PA 15236, USA; [2]NETL Support Contractor, 626 Cochran Mill Road, Pittsburgh, PA 15236, USA

Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications

Study Highlights

- The goal was to generate geologic realizations capturing the range of possible porosity and permeability distributions of the subsurface at the Illinois Basin - Decatur Project (IBDP) site, based on available site characterization data and inherent uncertainty of those data.
- The primary ensemble of 100 geologic realizations of the IBDP reservoir generated were used by SMART Task 5 teams to build their forward modeling, history matching, and optimization workflows.
- The geologic realizations were also ranked according to static and dynamic measures of connected volume analysis and hydraulic diffusivity.

Site of Interest - IBDP

- Reference Static Earth Model (SEM) of the IBDP site is a 9.7 mi x 9.3 mi heterogeneous reservoir model representing the Eau Claire through the Precambrian formations.
- This model version has 1.73 million grid cells in a global tartan grid configuration with the finest grid cells being 100 ft x 100 ft around the wells and the largest grid cells being 2,100 x 2,100 ft.

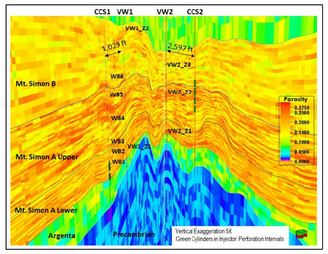

Figure 1. IBDP Project location in Decatur Illinois. Illinois Basin in blue.

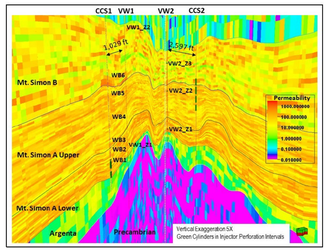

Figure 2. Upscaled porosity (top) and permeability (bottom) cross-section profiles with the injection and monitoring wells in the IBDP Model.

Workflow

Input: Reference SEM loaded into Petrel consisted of three property models of interest (facies, porosity, permeability) that were all tied to their respective well logs and variograms.

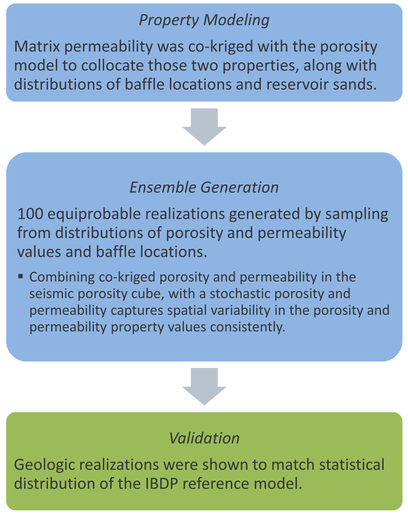

Figure 3. Revised ensemble generation workflow.

Validation: Qualitative and quantitative validation of new model realizations generated using the revised workflow to the original model realization.

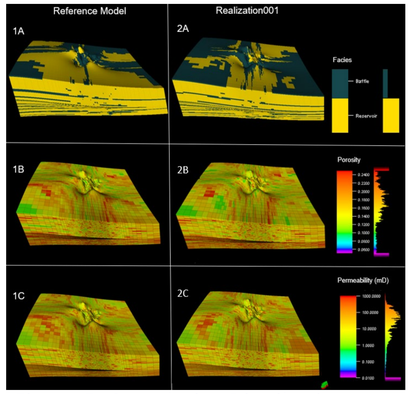

Figure 4. Original reference IBDP property model (1) and ensemble property model from new merged realization 001 (2) for Mount Simon zones.

(A) Facies models in which baffles are dark green and fluvial sands are yellow, (B) Porosity property model, and (C) Permeability property model.

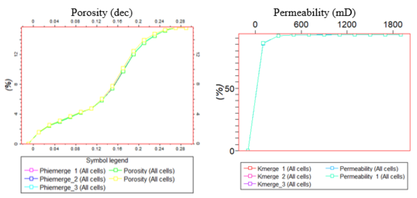

Figure 5. Cumulative Distribution Frequency plots of the porosities (left) and permeabilities (right) of the new property models and original model; as well as previously created realization.

Ranking of Realizations

- Goal: Identify a percentile rank of each of the 100 ensemble realizations of the IBDP site using two model analysis tools, one static and one dynamic.
  - **Static Ranking:** The Connected Volume Analysis (CVA) tool in Petrel gives a static measurement of the amount and size of the connected volumes of chosen reservoir quality (permeability grid cell of at least 100 mD in the targeted reservoir) in the model realizations.
  - **Dynamic Ranking:** The LINK-WellOpt Petrel Plugin enables ranking of realizations via the dynamic measure of hydraulic diffusivity for a first-pass analysis of the realizations because the analysis determines how much energy transfer can occur from the injection well.
- Ranking results: Histograms of the ranking results for the reservoir zone (Lower Mount Simon A zone), and tables noting the percentile ranks of the 100 realizations for comparison of the methods.
- Two different rankings, with no observed correlation can be relevant independent of each other, based on the research questions asked.

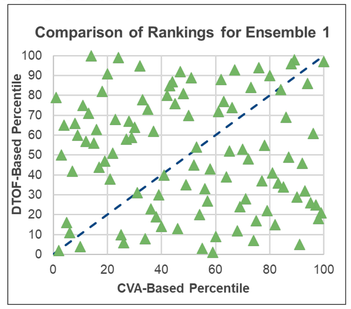

Figure 6. Comparison of percentile rankings for Ensemble 1.

References

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- Greenberg, S. 2021. "Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IBDP) Geological Models, July 7, 2021. Midwest Geological Sequestration Consortium (MGSC) Phase III Data Sets. DOE Cooperative Agreement No. DE-FC26-05NT42588.". United States. https://doi.org/10.18141/1854141.

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