PS Outcrop-Based Reservoir Modeling of the Sappington Formation (Montana); Developing Strategies for Reservoir Characterization and Modeling of Middle Bakken Reservoirs (North Dakota)*

Douglas Palkowsky[1], Iwan Harmawan[1], Rick Beaubouef[1], John Hohman[1], John Guthrie[1], Aaron Rodriguez[1], and Katy Sementelli[1]

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[1]Hess Corporation, Houston, Texas, United States (dpalkowsky@hess.com)

Abstract

A key challenge facing us is how to best describe and model the geologic characteristics of Bakken reservoirs in the context of limited subsurface spatial information and practical limits to numerical model size. How do we create geologically meaningful reservoir models that are also computationally efficient? To determine the most appropriate strategies for reservoir modeling of the Bakken Formation, Williston Basin, we have completed a suite of geo-cellular models using outcrop information from the Sappington Formation, SW Montana. The Bakken and Sappington formations are time-equivalent (Mississippian-Devonian) and share many geologic attributes owing to similarities in depositional histories and environments. Hence, the outcrops offer clues about subsurface reservoir heterogeneities that may affect production characteristics. Specifically, some outcrops reveal stratigraphic and facies variability over a scale that is similar to a Bakken Drill Spacing Unit (DSU). We present study results from one such outcrop and highlight the impact of geologic variability at a range of model resolutions. The first step was to create a high-resolution, DSU-scale model to approximate the vertical and lateral geologic variability observed in the outcrop. Bakken reservoir petrophysical properties were assigned to the model. Next, a suite of progressively coarser models were created and compared to the high-resolution model. This process entailed subjecting the original model to a “scale-up experiment” and documenting successive changes to the model design characteristics. Finally, we analyzed the models in terms of their petrophysical properties (connected pore-volume) as a method of screening for expected dynamic (simulation) behavior. Together, these results reveal the scale of resolution at which the geologic characteristics of the outcrop were lost in the scale-up process and simulated fluid flow characteristics are compromised. In ongoing and future phases of work, we will incorporate results of a behind-the-outcrop coring program, create a suite of simulation models to analyze their dynamic behavior and analyze the impact of inclusion of natural and induced fracture networks.

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Hess Corporation, 1501 McKinney Street, Houston, TX 77010

ABSTRACT

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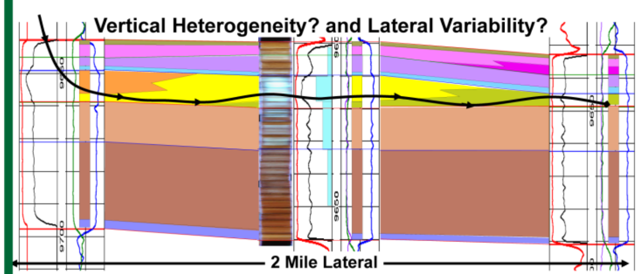
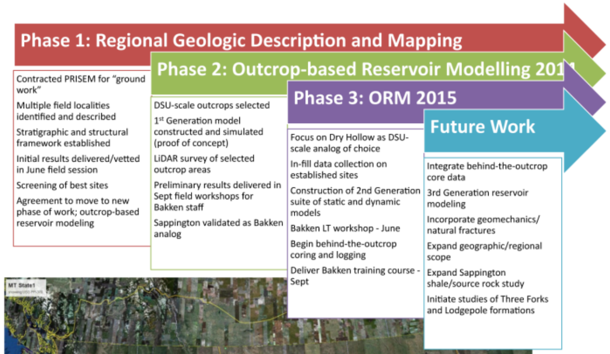


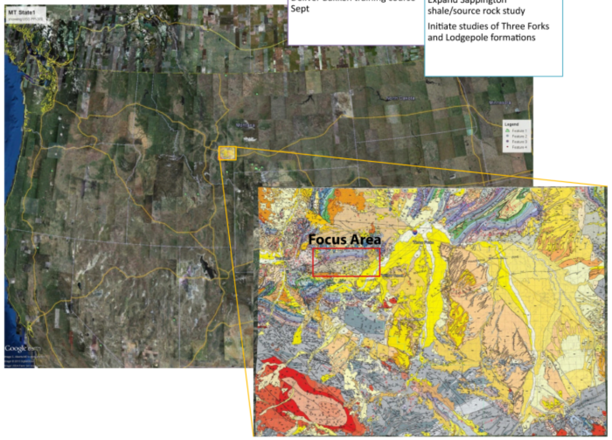
Three related Sappington papers are being presented in this conference

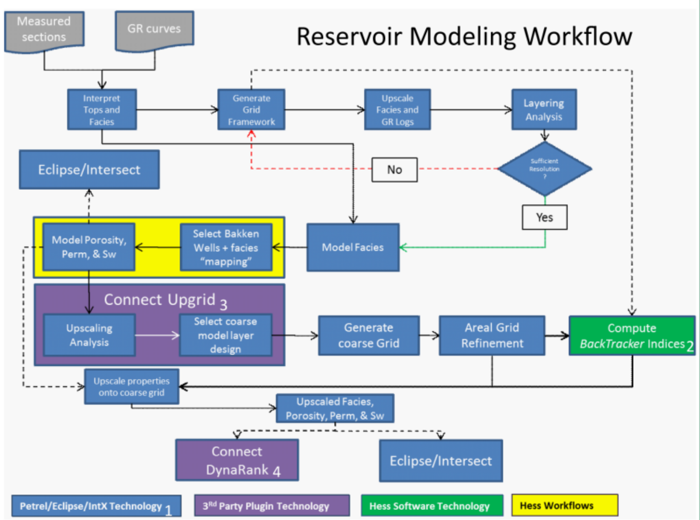
1. *Beaubouef, et al*; An Overview of the Sappington Project with Implications for future Generations of Bakken Reservoir Evaluations
Monday Poster

2. This study.

3. *Hohman et al*; Stratigraphy and Sedimentology of the Sappington Formation: Validating Sappington Outcrops as an Exposed Analog for the Bakken Subsurface
Tuesday 8:05 Oral

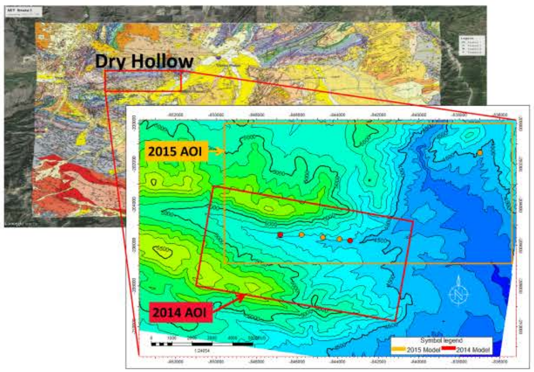




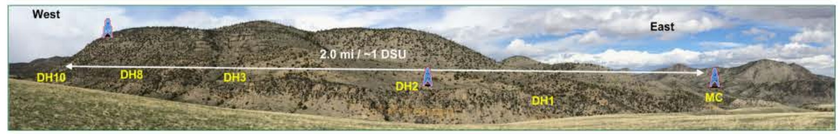


Sappington Reservoir Modeling Workflow; Milligan Canyon (MC) - Dry Hollow Focus Area

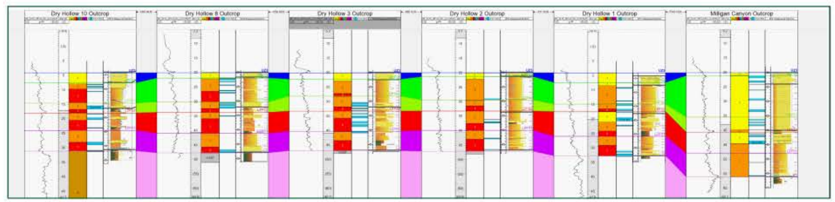
Outcrop Location



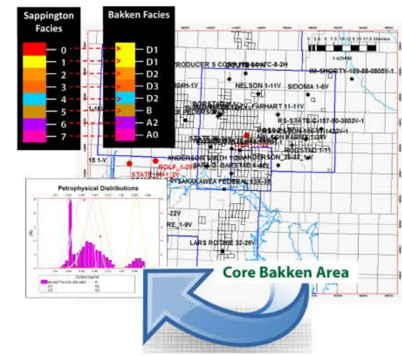
Dry Hollow - Milligan Canyon Focus Area

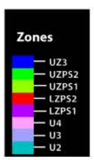


Outcrop Observations and Interpretation



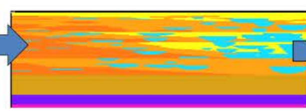
Association with Bakken Data



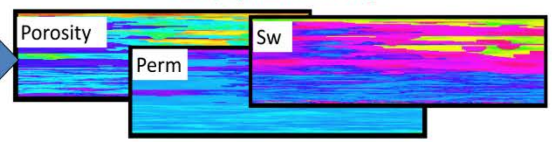


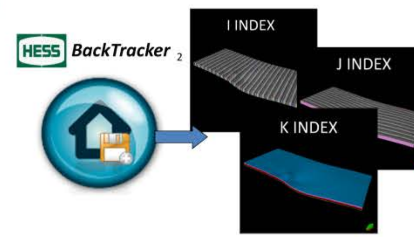
Framework Construction

Facies Modeling

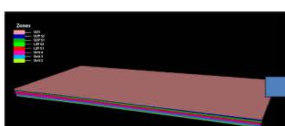


Petrophysical Modeling

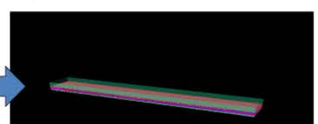




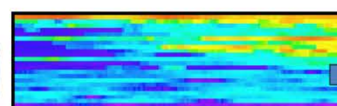
Preparation for fluid-Flow Simulation



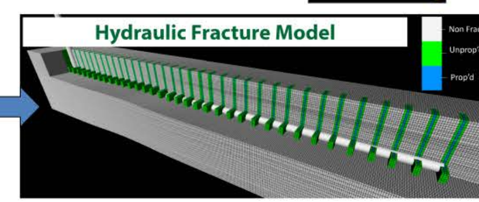
Areal Refinement, Datum and Flattening



Grid Cropping – Lateral Well Volume

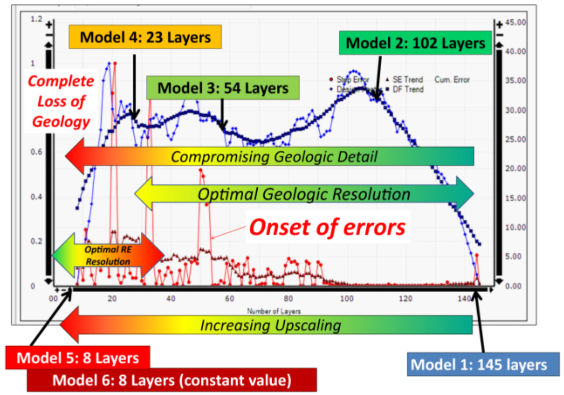


Upscaled Reservoir Property

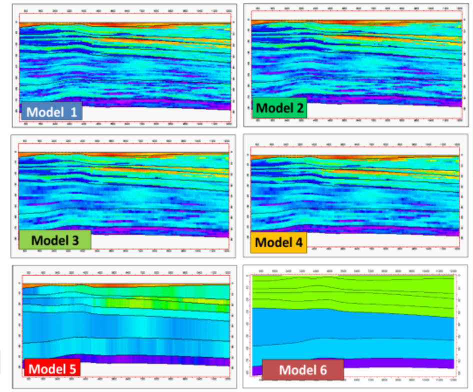


What degree of Resolution is required to Model DSU-Scale Heterogeneity?

Grid Upscaling Analysis [3]



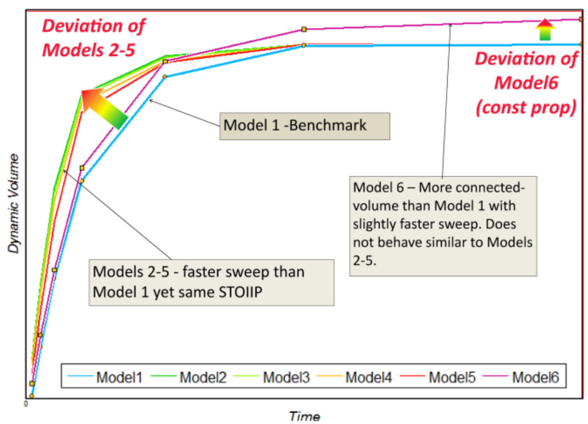
Upscaled Properties Comparison



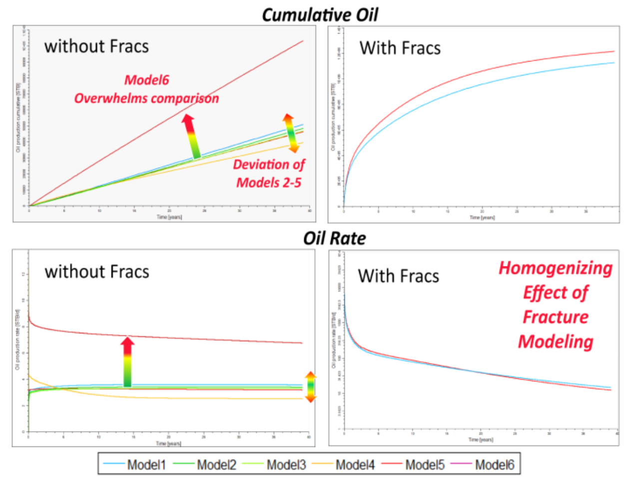
Model	Resolution	# Cells (10^3)	# Active Cells (10^3)	STOIIP (stb)
Model1	High	22,731	4,371	4,966,000
Model 2	⋮	15,990	3,075 m	4,966,000
Model 3	Medium	8,654	1,628	4,966,000
Model 4		3,606	693	4,966,000
Model 5	⋮	1,254	241	4,966,000
Model 6	Low	1,254	241	5,289,000

STOIIP Maintained

Dynamic Connected Volume Analysis [4]



Simulated Results



Conclusions

- **Inclusion of geologic heterogeneity impacts dynamic behavior**
- **Model resolution needs careful attention; scale-up experimentation**
- **Impact of hydraulic fracture modeling method can overwhelm geologic "signal"**

Future Work:

- **Incorporation of natural fractures (geomechanical modeling)**
- **Impact of model resolution on hydraulically stimulated fracture behavior**
- **Efficient analysis technologies (Lean model manufacturing)**

Acknowledgements

1: - Petrel, Eclipse, Intersect; Schlumberger

2: HESS - BackTracker, Patent Pending - Hess Corporation

3: CONNECT - Connect Upgrid, Kelkar & Associates

4: CONNECT - Connect DynaRank, Kelkar & Associates