Increasing the Accuracy of Reservoir Characterization in Unconventional Reservoirs*

Bradley Melton[1] and Neil Fishman[1]

Search and Discovery Article #41409 (2014)**
Posted August 11, 2014

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014

[1]Hess Corporation, Houston, Texas (bmelton@hess.com)

Abstract

As unconventional resource plays become more prevalent in the industry, an increasing amount of work is being done to characterize the geological details of these reservoirs properly. There is often a disconnect, however, between the detailed characterization being performed at the core and log scale and the Geomodels being built for reservoir simulation, volumetric analysis, and hydraulic fracture simulation. This disconnect is a result of the interpreter's desire to create a model that accounts for all of the available geologic detail and the simulator's desire for models that are small enough to run efficiently. The work presented here outlines a workflow-based approach for creating models that balance this tradeoff. Using data from an onshore US unconventional resource play, a workflow was generated to characterize the value of building detailed geologic models statistically in order to predict rock characteristics (e.g. porosity) away from well control. Different models of varying geologic detail were constructed. The results indicate that incorporating geologic detail into Geomodels does increase the ability of the model to predict porosity away from well control accurately (> 20% increase), but there is a point at which additional detail does not increase the predictive capability of the model. These results presume that the porosity depends on depositional environment or facies. 2D variogram analysis assists in quantifying the value of carefully modeling geologic detail in Geomodels. Within the study area, models with zonation schemes that lump differing geologic environments result in variogram maps containing too much information. However, properly splitting different geologic environments into their own model zones yields 2D variograms that contain adequate information and are easier to incorporate into models. The statistical and variogram analysis utilized in this study illustrates the impact of geologically reasonable models upon unconventional resource plays. These models take more time to build than models without built-in geologic concepts, but the resulting property distributions are more meaningful. Utilizing this workflow within a given reservoir of interest can indicate the correct number of zones for maintaining geologic heterogeneity, while helping to satisfy the demands of the simulator. Ultimately, accurate rock predictions will yield better STOOIP calculations, DFN models, and well planning/geo-steering plans.

References Cited

Egenhoff, S.O., and Fishman, N.S. 2013, Traces in the dark - sedimentary processes and facies gradients within the Upper Devonian-Lower Mississippian upper shale member of the Bakken Formation, Williston basin, North Dakota, USA: Journal of Sedimentary Research, v. 83, p. 803-824.

Egenhoff, S.O., A. van Dolah, and A. Jaffri, 2010, Unconventionally conventional - facies and sequence stratigraphy of the Upper Devonian - Lower Mississippian Bakken Formation reservoir, Williston Basin, North Dakota: Search and Discovery Article #10257 (2010). Website accessed July 17, 2014. http://www.searchanddiscovery.com/pdfz/documents/2010/10257egenhoff/ndx_egenhoff.pdf.html

Leszczynski, S., B. Kołodziej, D. Bassi, E. Malata, and M.A. Gasinski, 2012, Origin and resedimentation of rhodoliths in the Late Paleocene flysch of the Polish Outer Carpathians: Facies, v. 58, p. 367–387.

Tucker, M.E., and V.P. Wright, 1990, Carbonate sedimentology: London, Blackwell, 482 p.

Increasing the Accuracy of Reservoir Characterization in Unconventional Reservoirs

B. Melton
N. Fishman

Agenda

- Overview
- Model/Workflow
- Results
- Uses of the Model

Agenda

- Overview
- Model/Workflow
- Results
- Uses of the Model

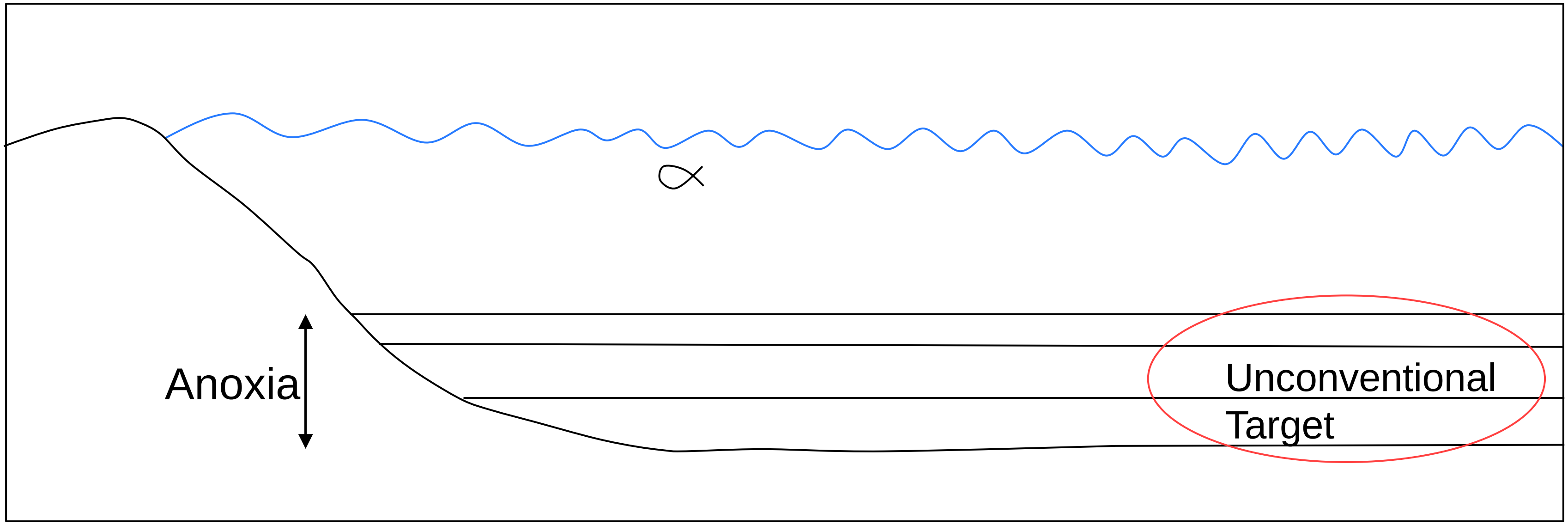
Overview

- Detailed Geologic Models
  - Tie core, log, and geologic observations together.
  - Increase the accuracy of physical property predictions (Porosity, Sw, etc.).
  - Enable accurate fluid and fracture simulations.

- Questions
  - How much detail do we really need? How do I know which model is best?
  - Will this really change my simulation results?
  - Can you incorporate detail without giving us models that are too big to simulate?

Regional Overview/Concept

The Traditional Model/Understanding of
Unconventional Reservoirs

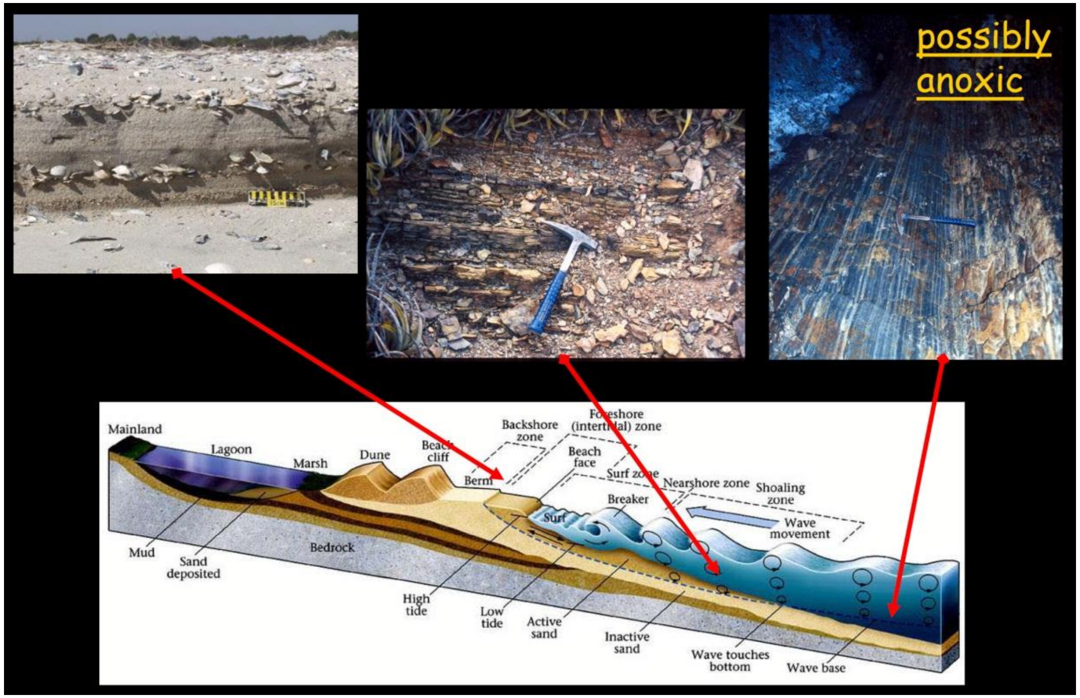


We are now finding that this model
is inaccurate for many basins.

Proper Understanding

It is important to understand that…

- **Depositional environments are not randomly distributed** across the platform, slope, or basin. **They form in response to well organized physical, biological and chemical processes.** (Loucks)

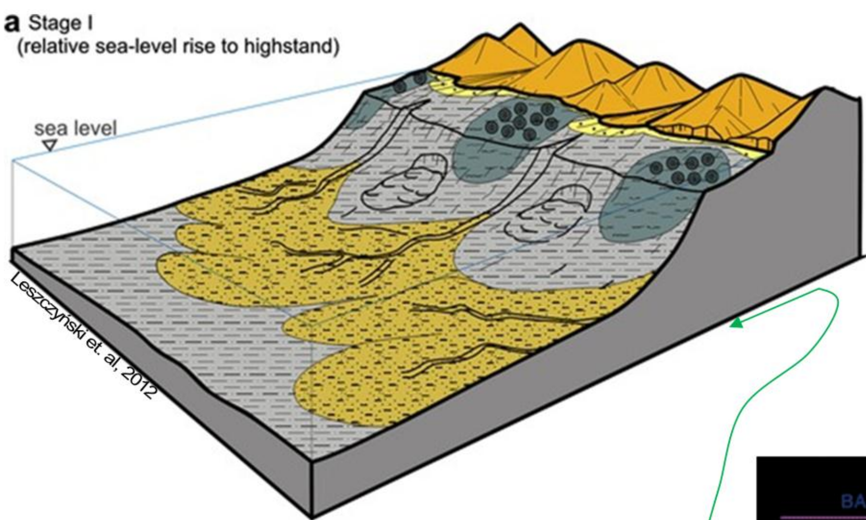


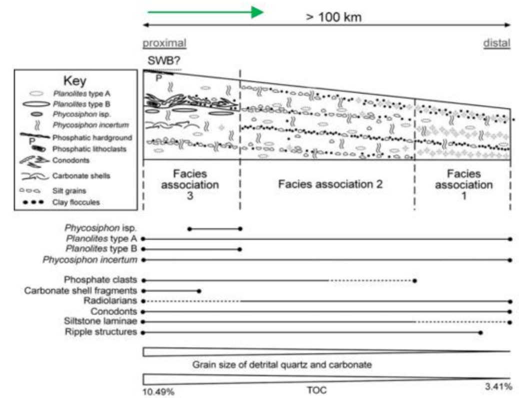
Egenhoff et al, 2010

Walther's Law states…

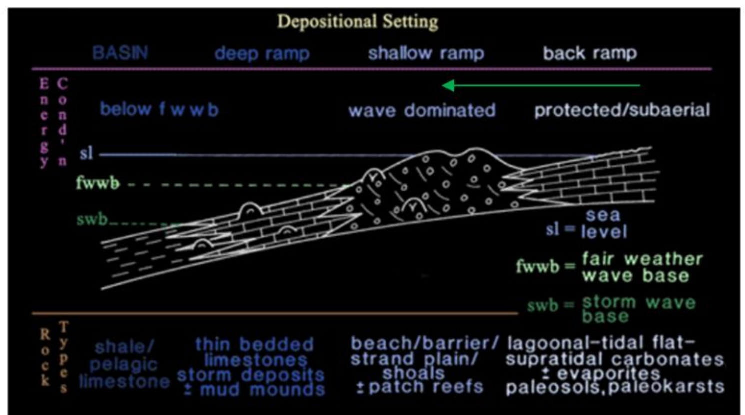
- Facies that occur in a conformable vertical succession also occur in laterally adjacent environments.
  - Implications—laterals have the potential to cross multiple facies.

Actual Unconventional Depositional Environments





Egenhoff and Fishman, 2013



Tucker & Wright, 1990

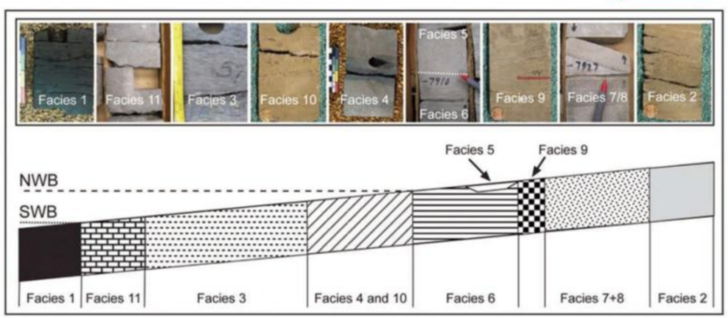
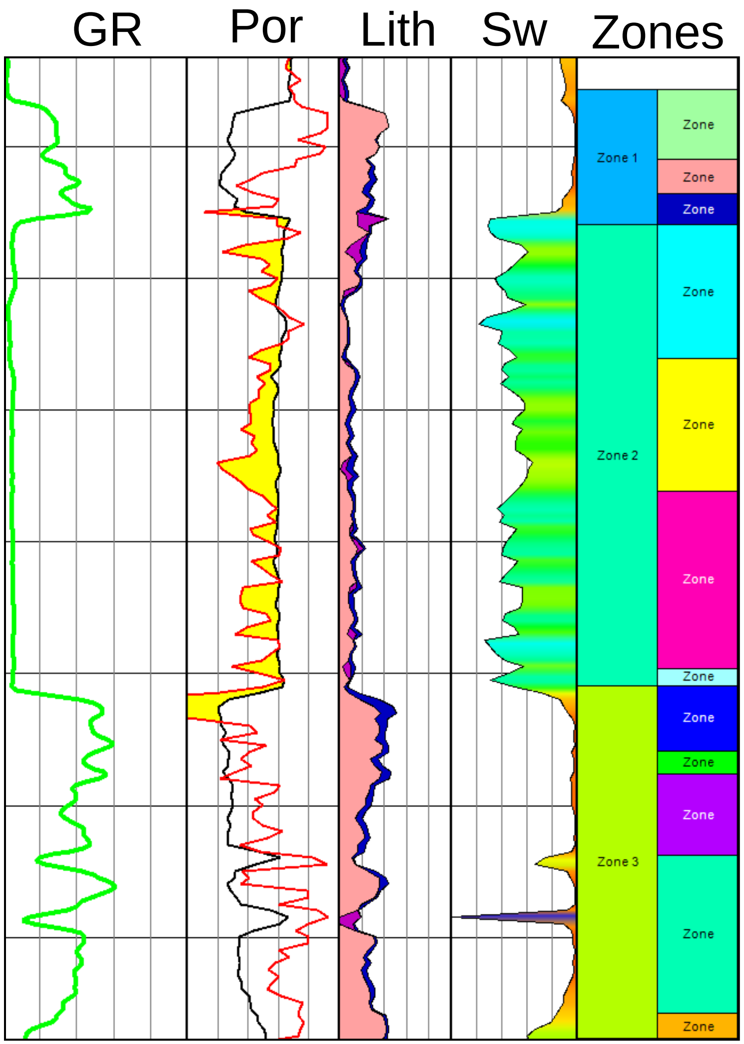


Figure 7. Depositional model showing the relative position of Bakken facies on a proximal to distal ramp transect. Note that this transect generally follows a decrease in grain size downramp with the exception of the inorganic siliciclastic silt- to mudstones (facies 2) which represent lagoonal facies in the most proximal areas.

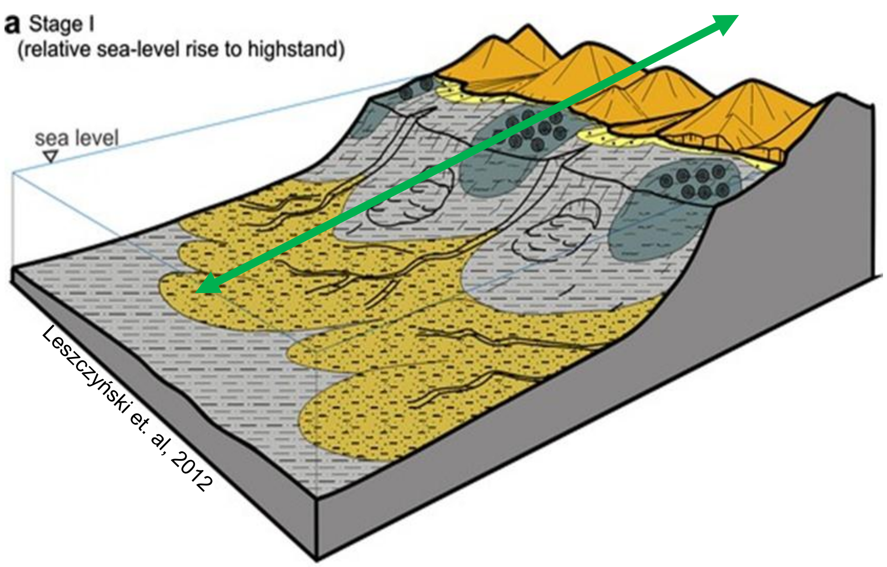
Egenhoff et al, 2010

Presenter's notes: These rocks were not deposited in deep-basin settings but in shallow, epieric seaways or in more shelfal settings. Ties to the upper shale member, being deep-water deposits, are therefore incorrect in that the upper shale was deposited in relatively shallow water in a more shelfal setting.

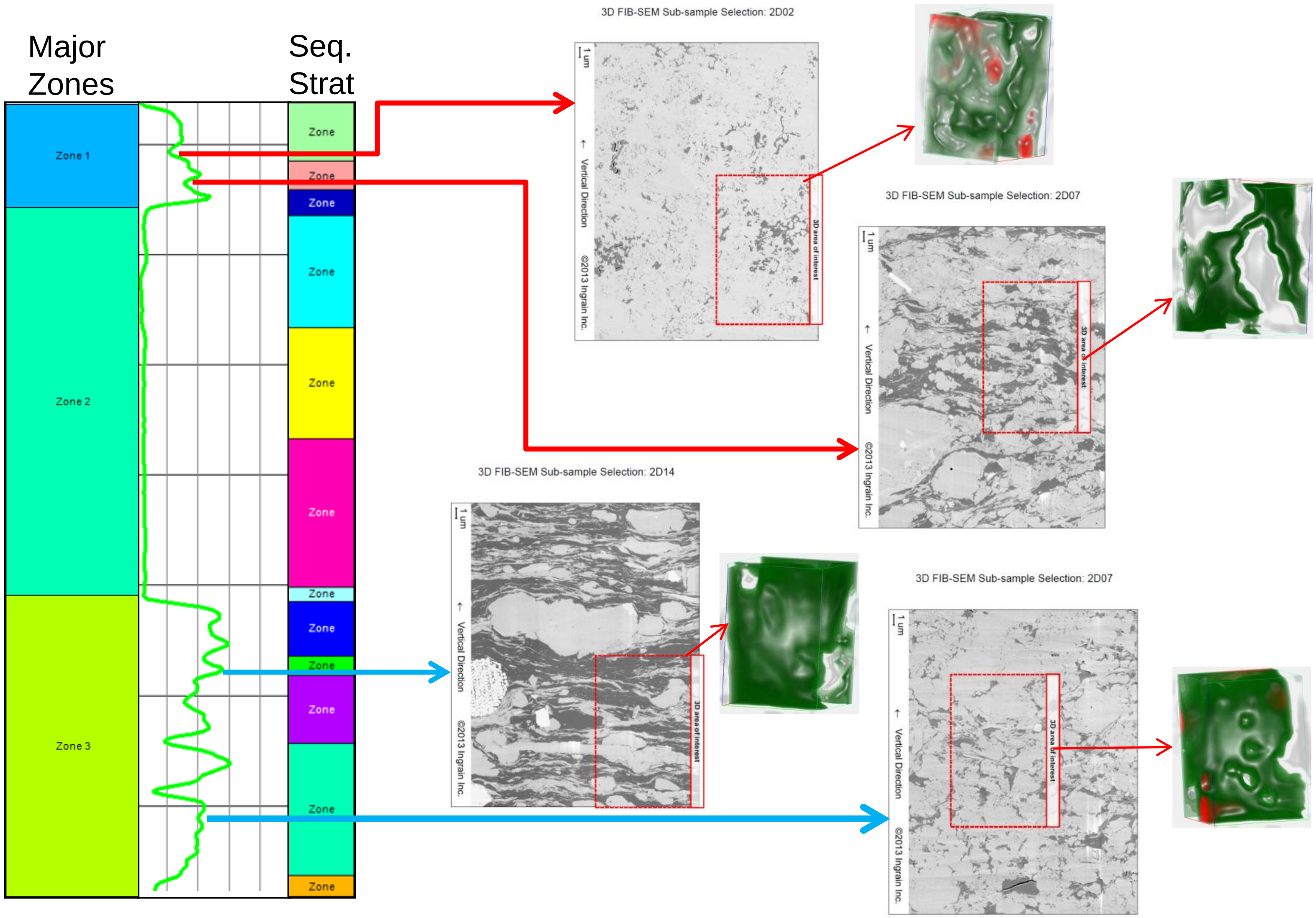
Type Log



Changes in the **Stratigraphic Intervals** (Zones) are tied to changes in the **Depositional Environment;** therefore, the physical properties are predictable laterally.



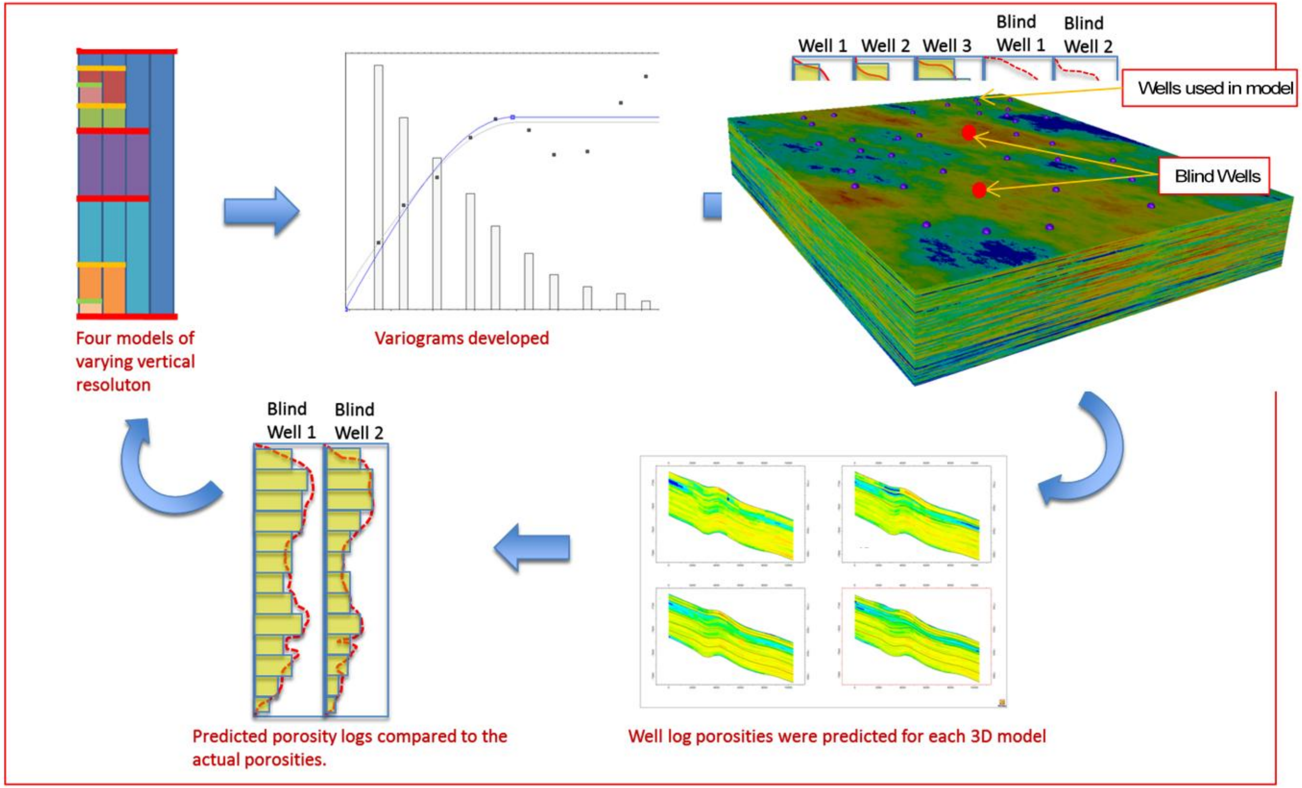
Another Consideration: Nano-Scale Heterogeneity



Agenda

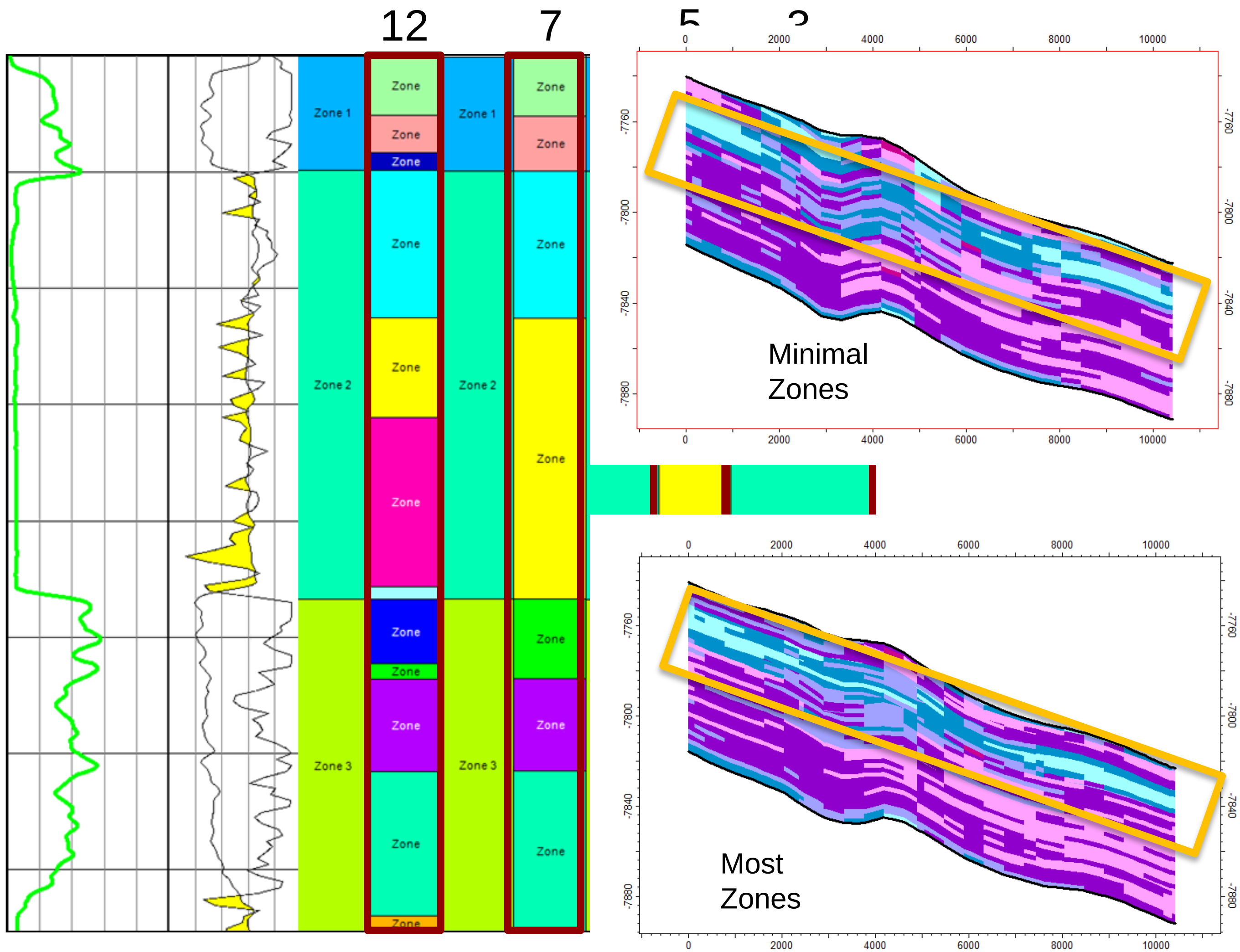
- Overview
- Model/Workflow
- Results
- Uses of the Model

Workflow



Presenter's notes: Created four models of varying vertical detail. Developed variograms for each model. Upscaled the porosity well log into each model; withheld blind wells for cross-validation tests. Predicted well log porosities for each 3D model. Extracted the predicted porosity logs at each of the blind well locations and compared them to the actual blind well log porosities.

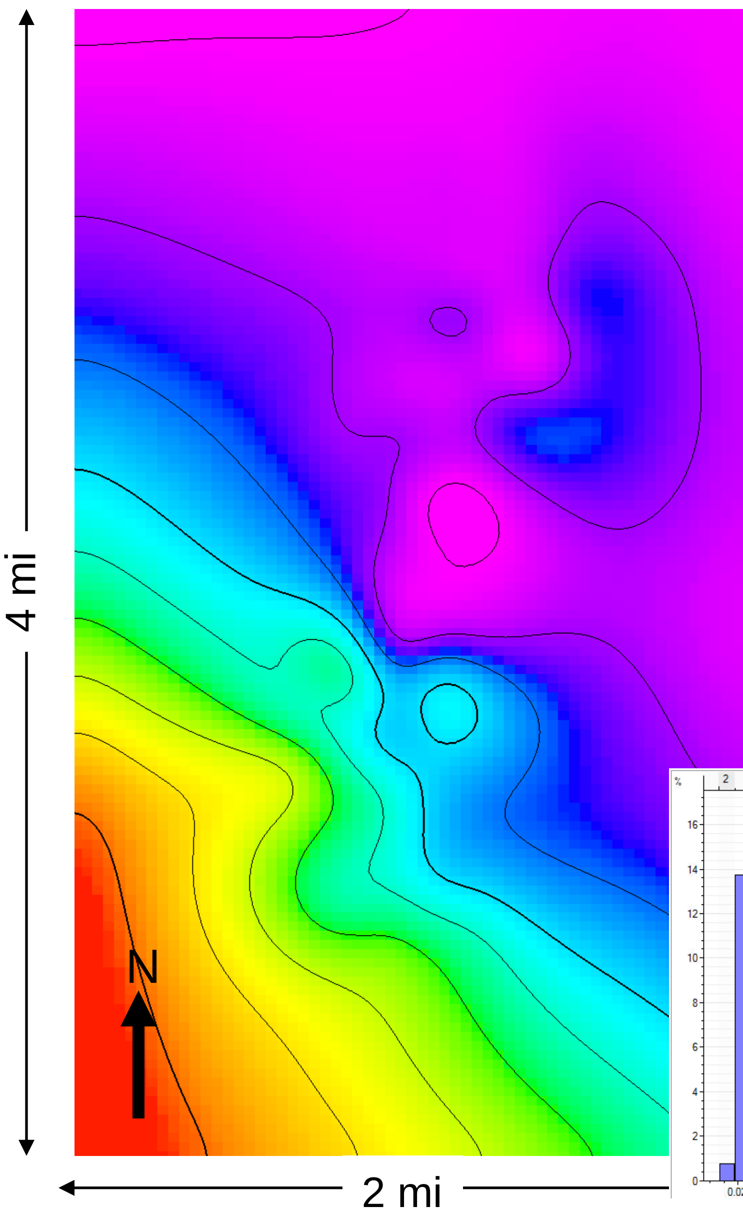
Review of the Models

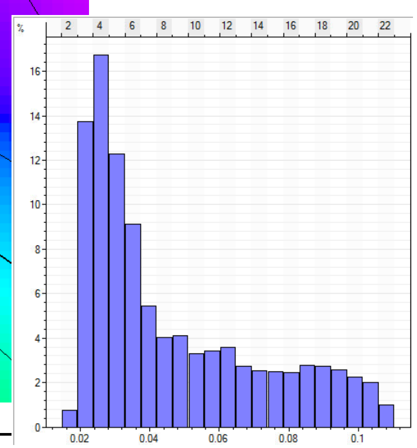


Agenda

- Overview
- Model/Workflow
- Results
- Uses of the Model

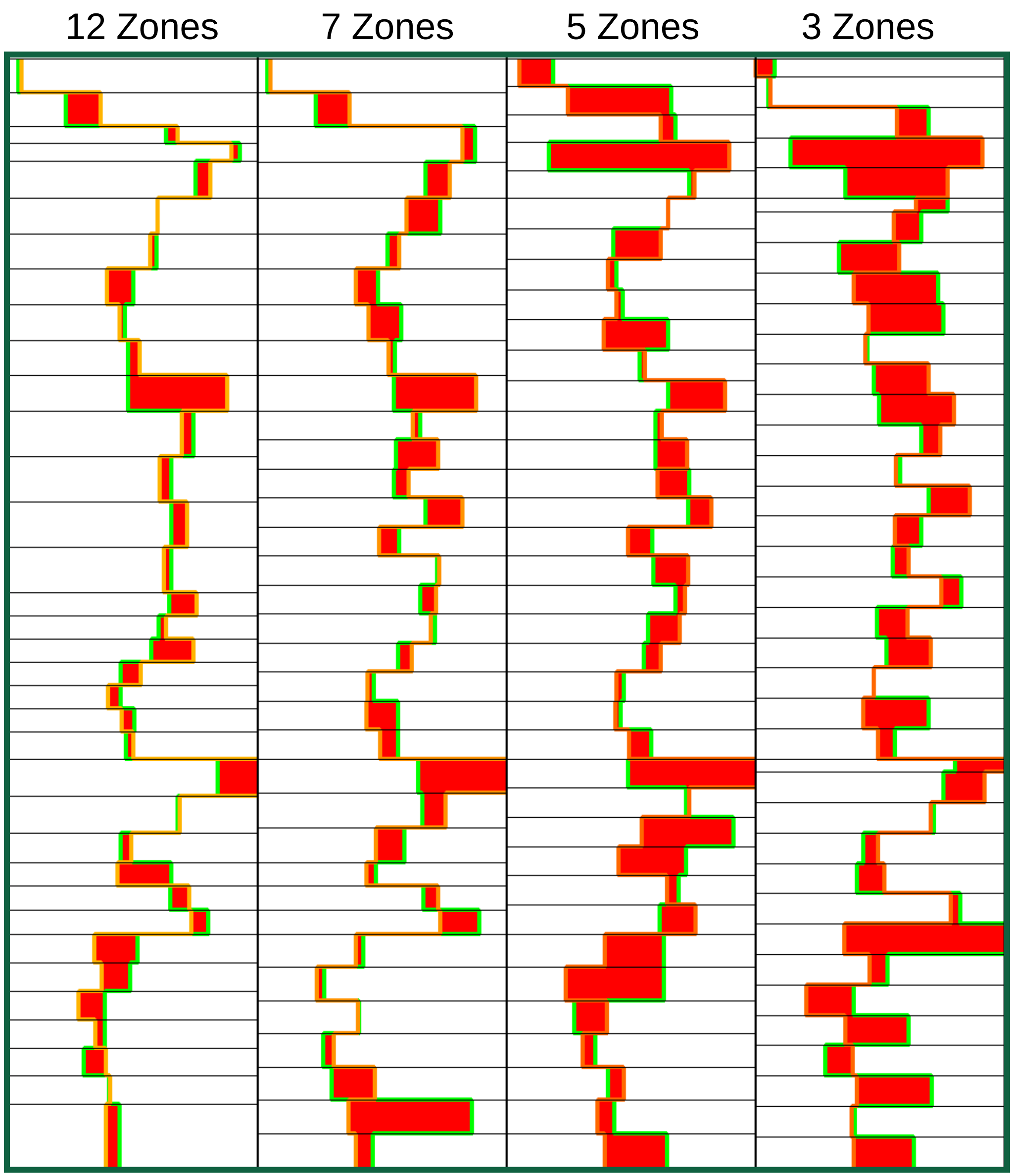
Can I Use Mean Values to Represent the Reservoir?





- Displayed: Mean Square Error from a portion of the 12 zone model.
- This is a relatively small area with a high amount of well control. Note that the Mean Square Error varies drastically across the area.
- One could not hope to capture the heterogeneity in the area just by using the mean.

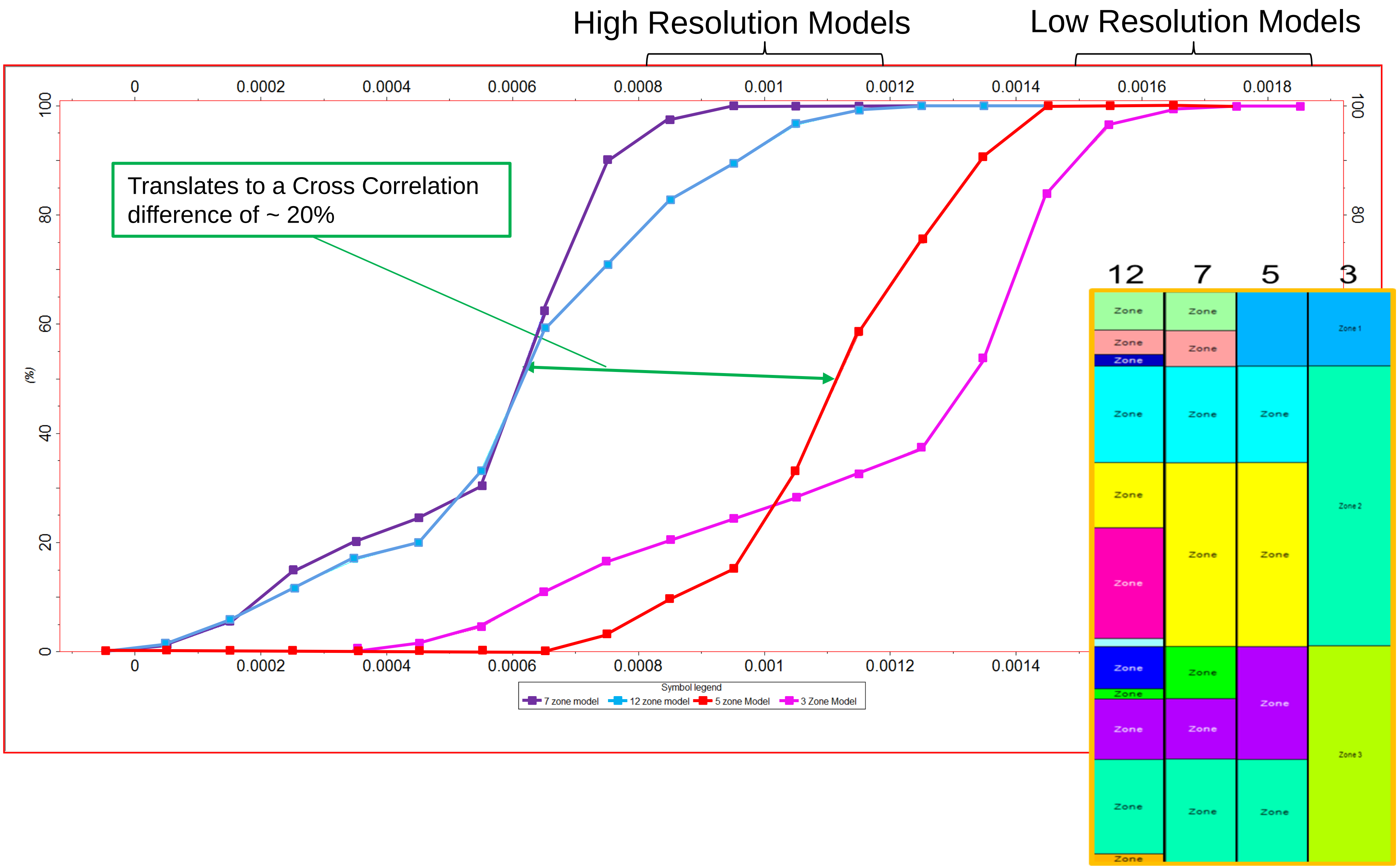
Visual Error in the Models (Single Well Example)



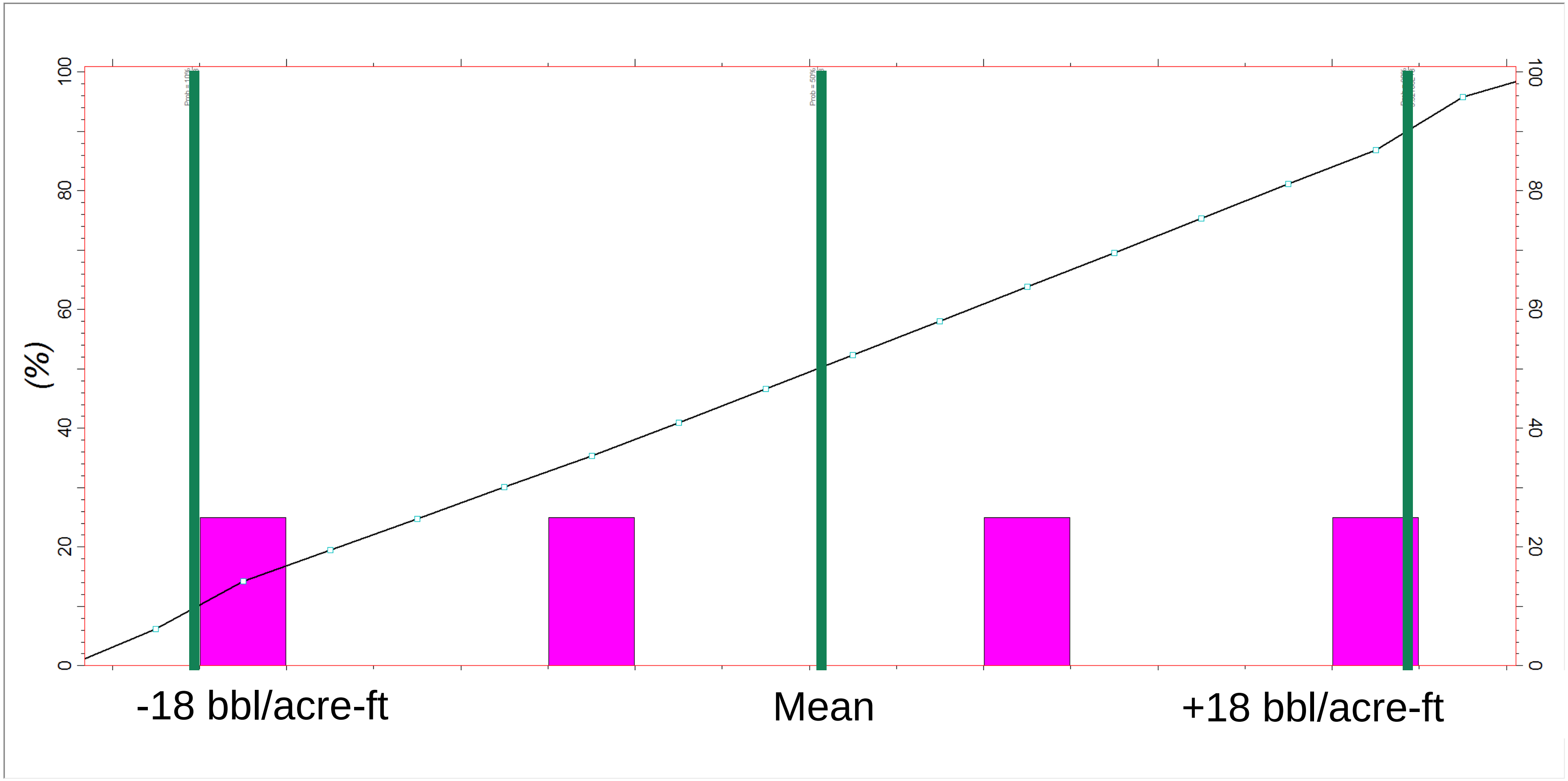
Green Line: Actual Porosity
Orange line: Predicted Porosity
Fill = difference

Zones:

Variance for all of the wells for each Model

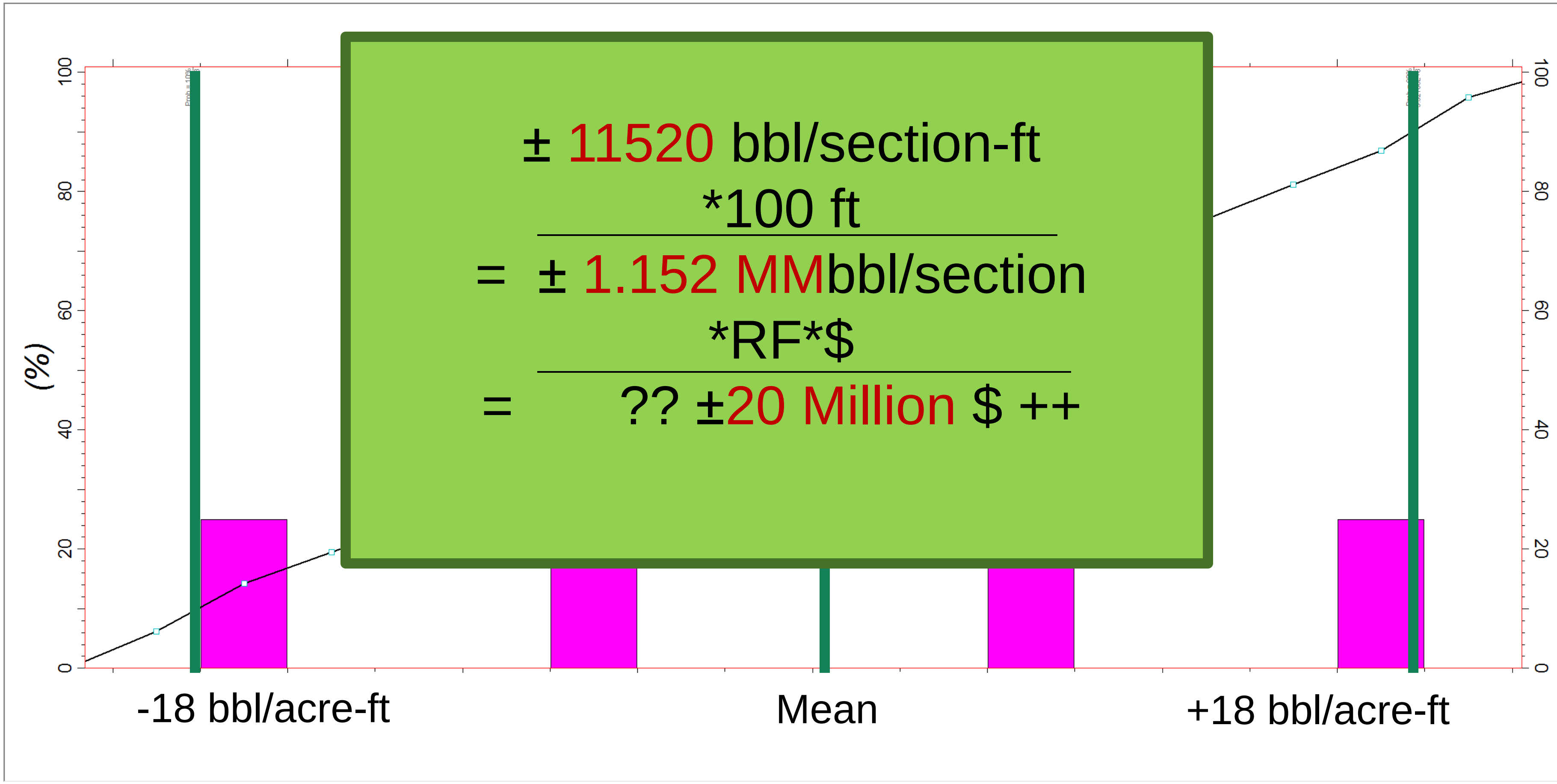


Ranges for the Four models: From Volumetric Calculation



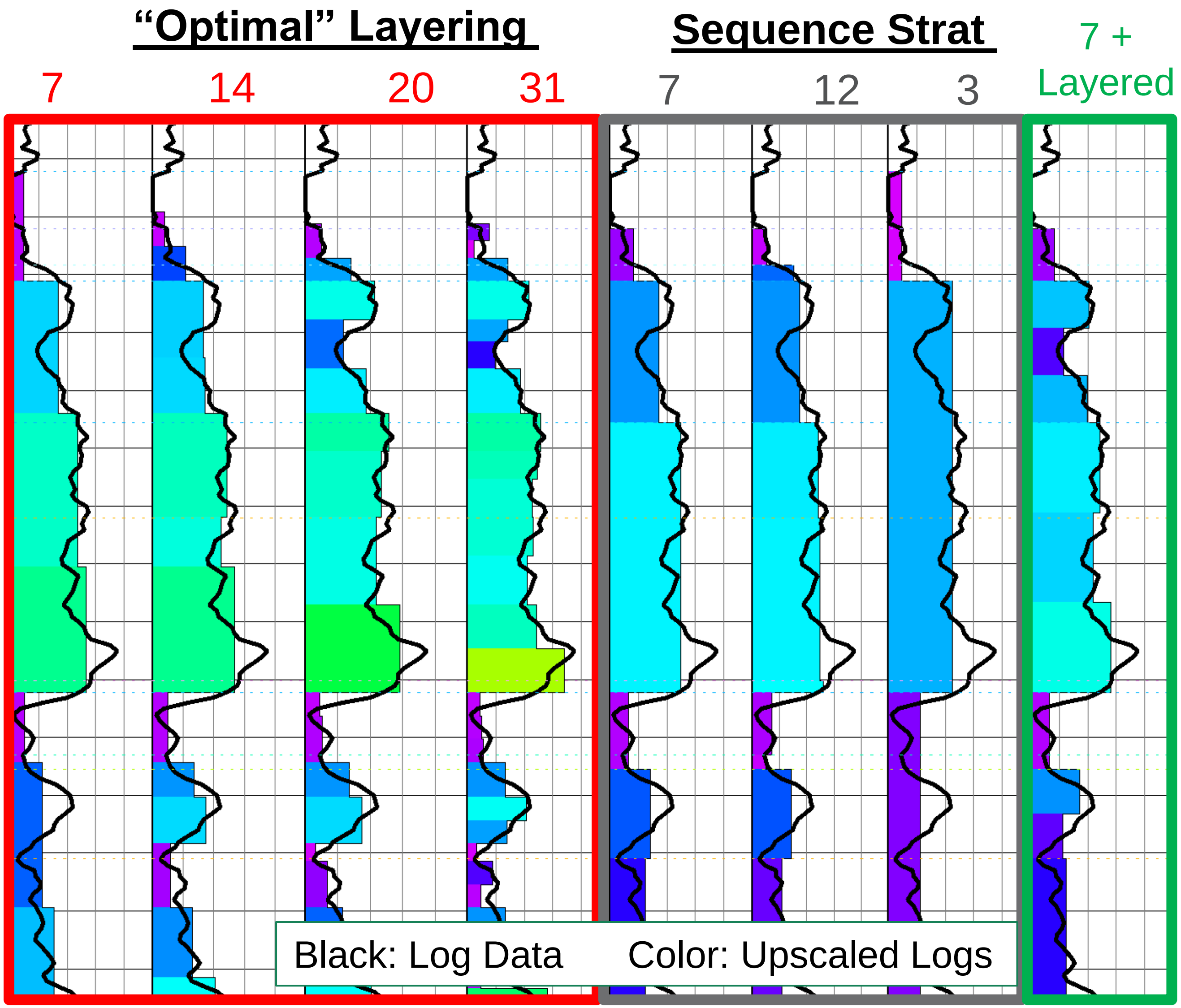
*STOOIP changes drastically when different models are used;, so it is important to use the **most accurate model.**

Ranges for the Four models: From Volumetric Calculation



*STOOIP changes drastically when different models are used; so it is important to use the **most accurate model.**

Simulation Model Size

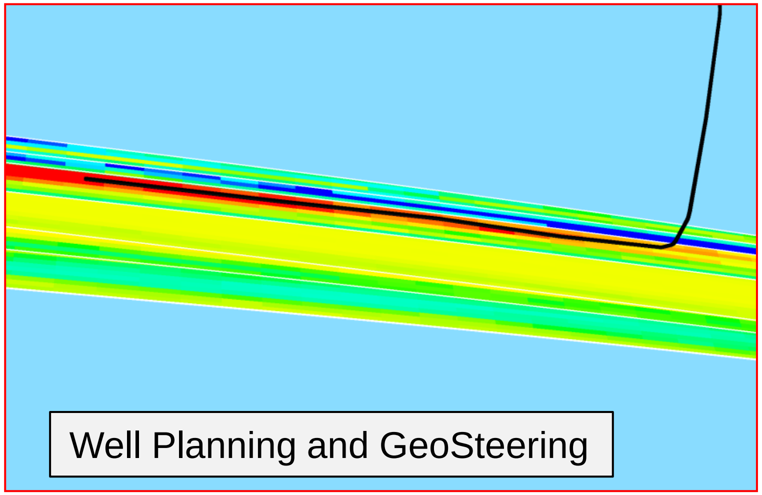


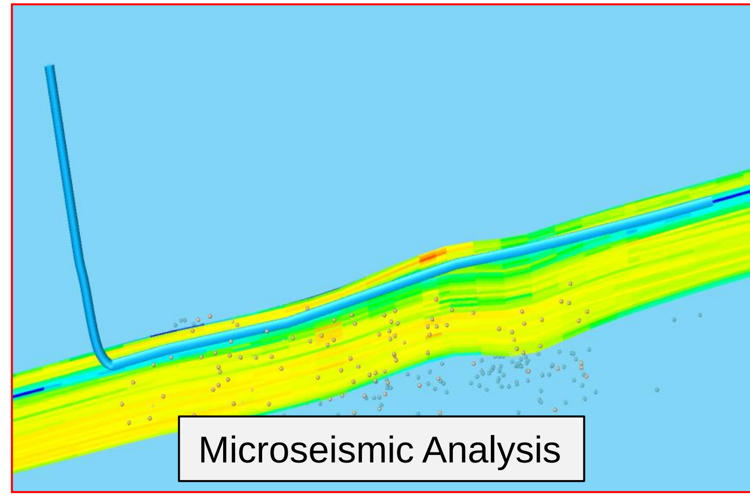
- "Optimal" layering techniques (such as Variance based methods) would predict that 20 to 31 layers are needed to achieve accurate matches to log data.
- Sequence Stratigraphic Methodologies would only require ~ 7-12 layers to sufficiently match log data (see 7+ Layer Case).
- This difference will cut simulation times in half.

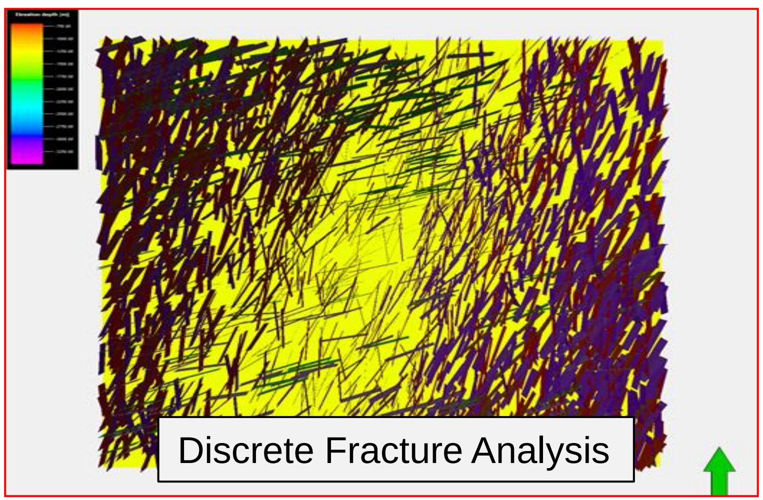
Agenda

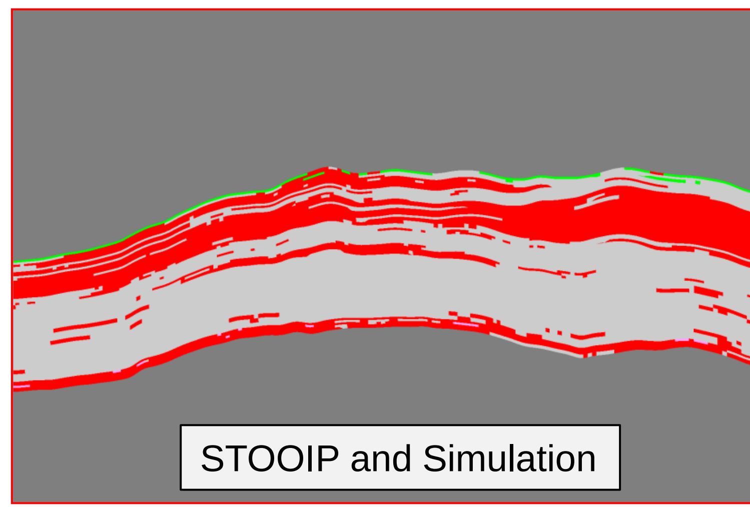
- Overview
- Model/Workflow
- Results
- Uses of the Model

Example Uses of the Models









Conclusion

- The integration of facies shows clear improvement in the prediction of properties in blind wells. Improvement of the predictions correlate with model detail, but only to a point.

HESS

Questions?