Property Modeling (Porosity and Permeability)

Currently, there are no deep wells at the HGSS to supply site-specific data for the confining zone and reservoir. The closest analog well is the TR McMillen 2 well that was drilled down to Precambrian basement rock (Error! Reference source not found.). Data from this well, including well logs and core samples, were used to determine the porosity and permeability of the injection and confining zones for the HGSS. Thus, this data serves as proxy or analog data in developing the SEM for the HGSS (**Figure 1**). Due to differences in formation thickness and depth between the TR McMillen 2 well and the HGSS, the following four-step method was used to synthesize well logs for the HGSS:

1) Regional surfaces, including the Eau Claire, Mt. Simon, and Precambrian Basement, served to define coarse model zones. A precursory one-foot proportional layering framework model was prepared within these zones between the TR McMillen 2 well and the HGSS.
2) TR McMillen 2 well logs, including gamma ray (GR), porosity, and permeability, were sampled into this high-resolution layering. Each layer received a homogeneous log value which was migrated to the HGSS wells.
3) At the HGSS, each proposed injection well was used to sample the finely layered property models at a 1-foot vertical resolution to synthesize logs.
4) These synthesized logs, like porosity and permeability, were saved for each of the six HGSS wells and were then available to serve as input to the subsequent petrophysical modeling.

Log preparation also involved calibrating the TR McMillen 2 permeability log to core points. For the lower Mt. Simon sections, in this case, model zones Mt. Simon A-lower, A-upper, and B, adjustments were made to the permeability log. Permeability data based on laboratory core data measurements for the TR McMillen 2 well showed that preliminary permeability logs underestimated permeability data from the lower Mt. Simon. While there was reasonable agreement between porosity logs and core-derived porosity data, an adjustment to the permeability log was deemed necessary. The core data appears to be representative of heightened permeability for the lower Mt. Simon, which is consistent with subsurface measures acquired in support of the IBDP and ICCS projects in Decatur[1]. Thus, a positive gain (adjustment) was applied to the permeability log for the Mt. Simon A and B zones, as depicted in **Figure 2**. The revised permeability log was labeled *KSDRadj* and used in the SEM for the HGSS.

[1] Leetaru, H.E., and Freiburg, J.T., 2014, Decatur Litho-facies and reservoir characterization of the Mt Simon Sandstone at the Illinois Basin – Decatur Project, Greenhouse Gases, https://onlinelibrary.wiley.com/doi/full/10.1002/ghg.1453

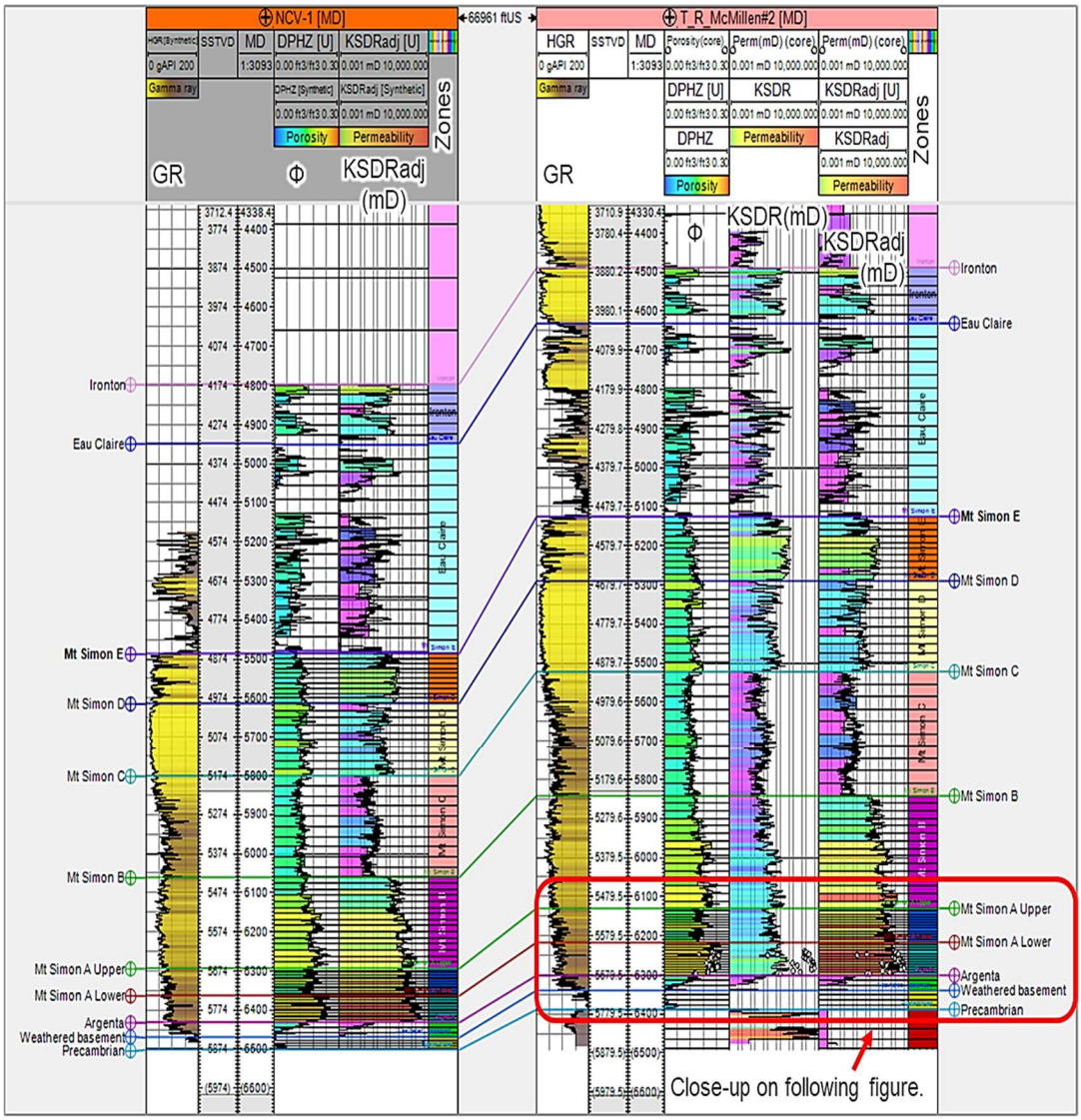

Figure 1. TR McMillen 2 well logs were adapted to HGSS using proportional layering, approximating differences in stratigraphic depth and formation thickness. TR McMillen 2 well logs serve as proxy logs for the proposed NCV-1 well at the HGSS site. The red region features core data used to correct or adjust the permeability log.

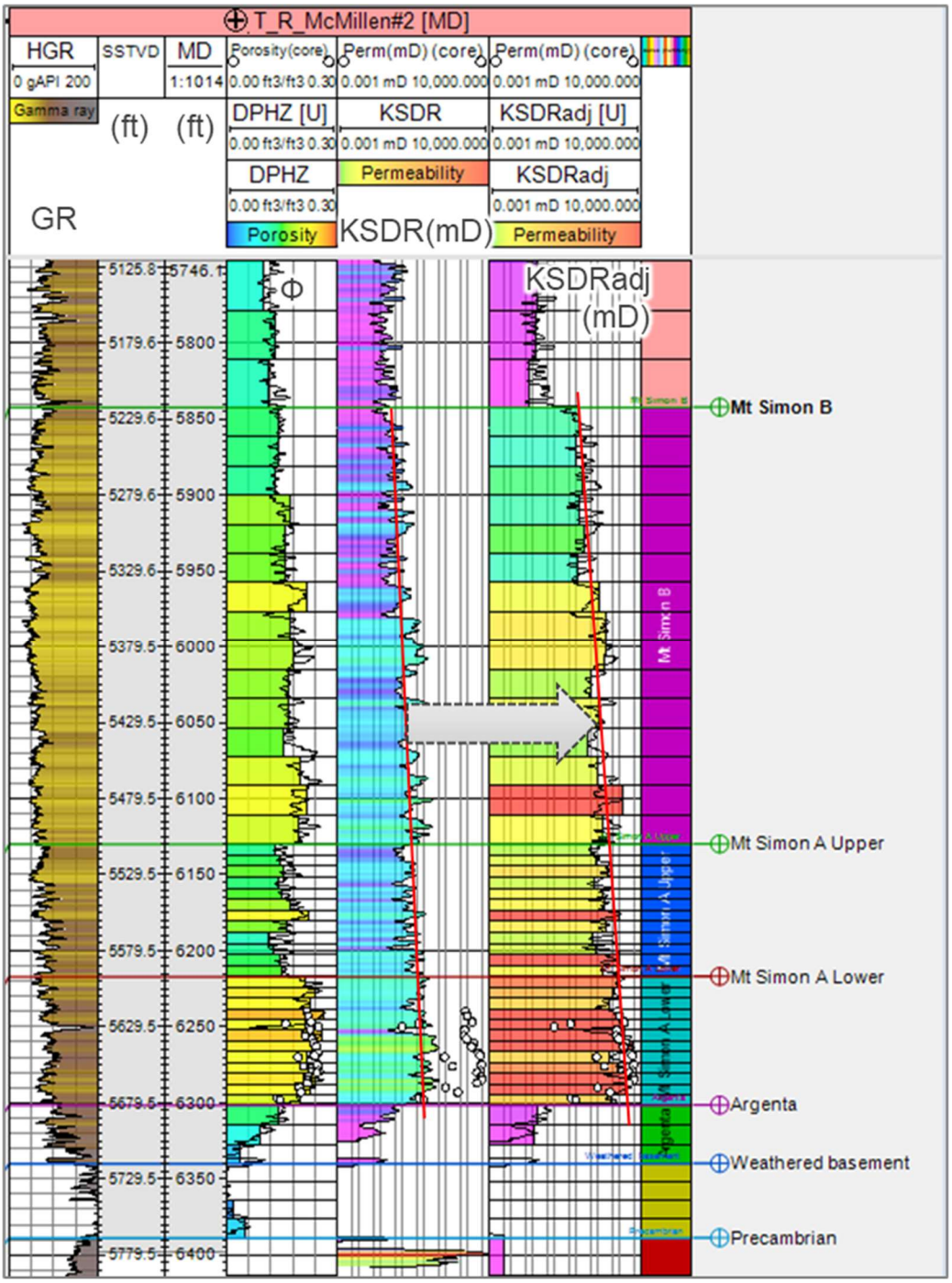

Figure 2. TR McMillen 2 well logs and core point data for the lower Mt. Simon. The porosity log was consistent with the porosity core data. The preliminary permeability log, KSDR, was adjusted to better align with core data points and is labeled KSDRadj. The gray arrow highlights the applied gain to the permeability log for Mt. Simon zones A and B.

The synthesized porosity and permeability well logs at the HGSS were upscaled along their well trajectories into the Tartan grid model cells and were distributed layer cake style, meaning that each model layer is homogeneous and isotropic. The layer cake modeling was conducted for the

Ironton zone down through the top 100 feet of the Precambrian basement, as shown in **Figure 3** and **Figure 4**. Model cross-sections through the HGSS further reveal the layer cake modeling of the petrophysical properties (**Figure 5**). Using the SEM, the average porosity and permeability were computed for each model zone and are reported in **Table 1**. Histograms of porosity and permeability for the Eau Claire confining zone and the entire Mt. Simon section reveals the contrast between these two geologic units (**Figure 6**).

Table 1. Average porosity and permeability values by model zone.

Model Zone	Avg. zone Porosity (ft3/ft3)	Avg.** zone Perm (mD)
Ironton	0.077	12.864
Eau Claire	0.059	2.932
Mt Simon E	0.127	20.373
Mt Simon D	0.145	3.349
Mt Simon C	0.120	0.489
Mt Simon B	0.173	144.689
Mt Simon A Upper	0.157	283.512
Mt Simon A Lower	0.228	1278.112
Argenta	0.078	0.073
Weathered basement	0.014	0.005
Precambrian basement	0.001	0.005
Model Base	-	-

** Avg permeability computed by the arithmetic mean method.

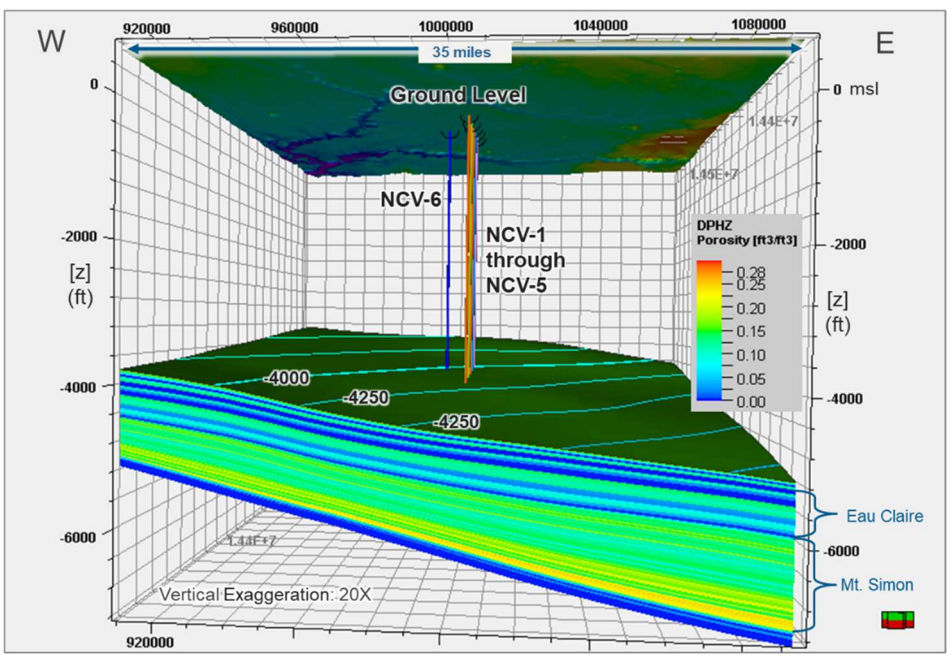

Figure 3. Oblique view of the 3D layer cake porosity model. Model zones dip to the southeast.

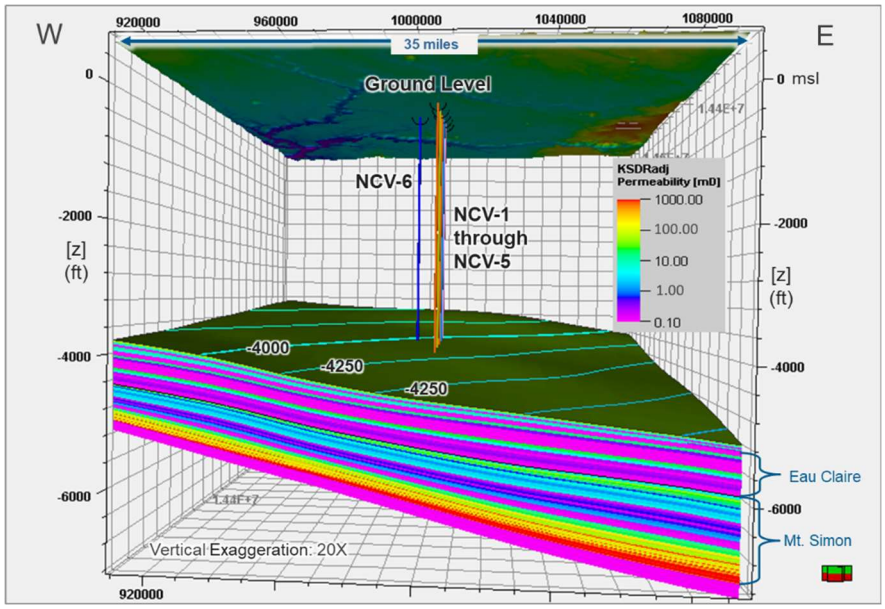

Figure 4. Oblique view of the 3D layer cake permeability model. Model zones dip to the southeast.

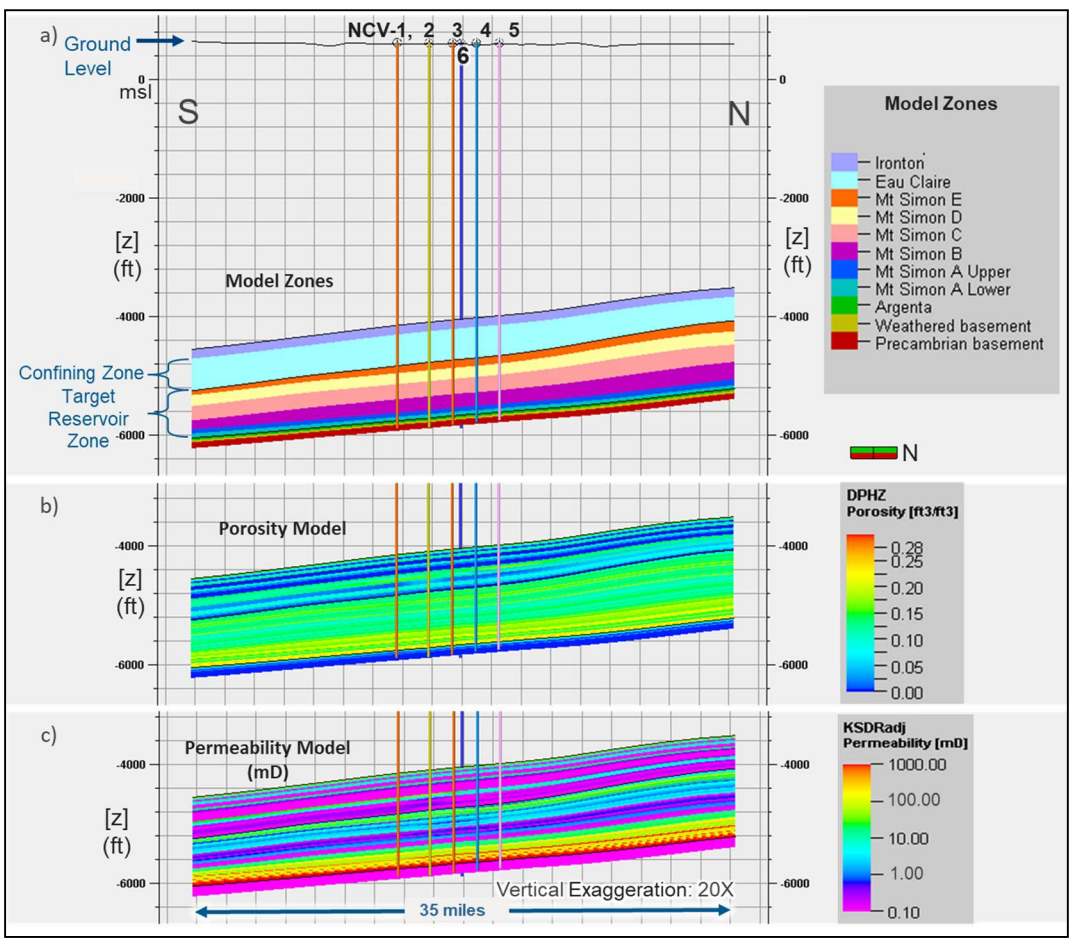

Figure 5. Model cross-sections. a) Model zones for petrophysical modeling. b) Layer cake porosity model. c) Layer cake permeability model.

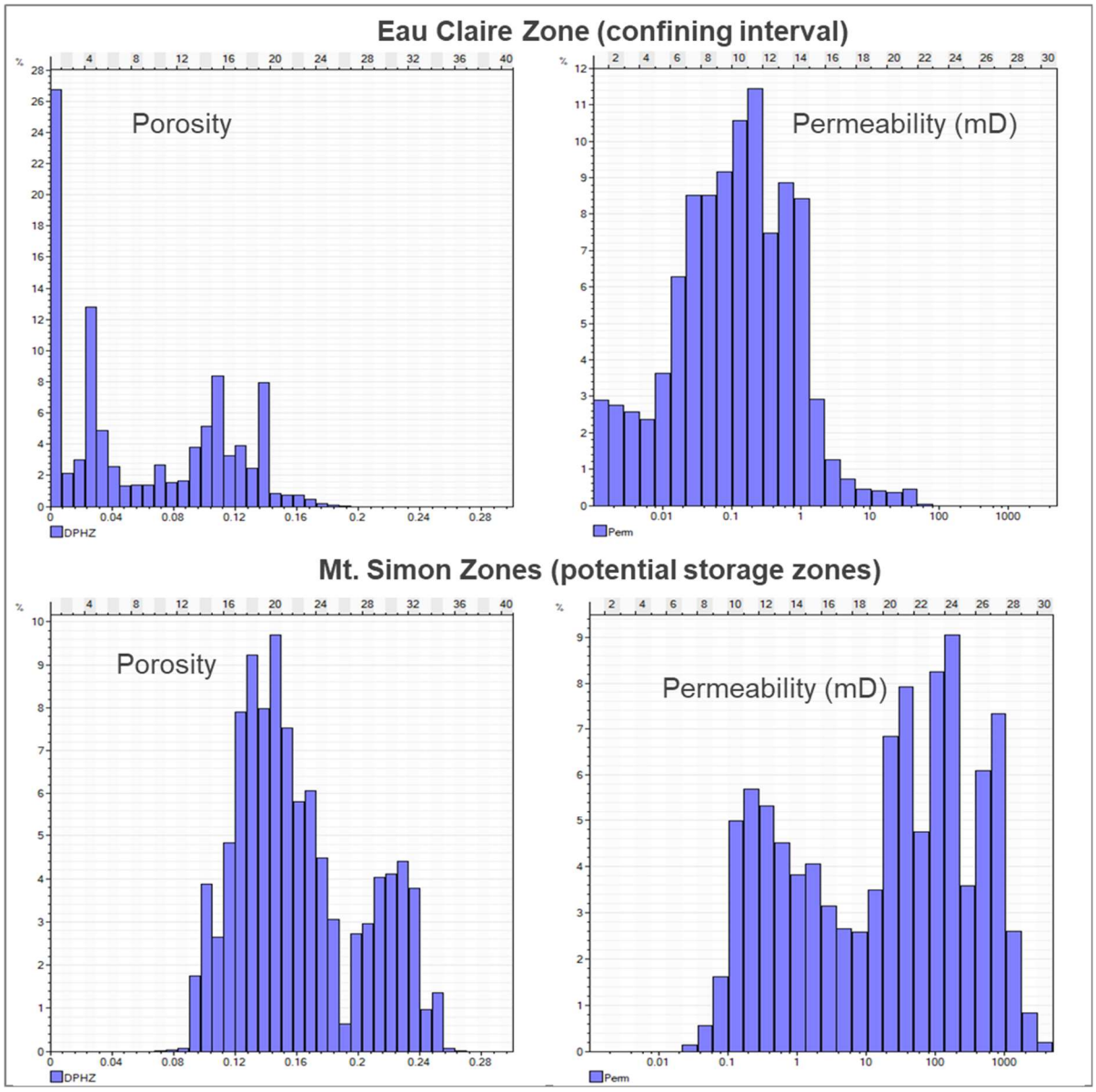

Figure 6. Histograms depicting porosity and permeability model distributions. Histograms are filtered by model zones, with the Eau Claire representing the confining interval and the Mt. Simon zones consisting of Mt. Simon E zone down through Mt. Simon A Lower.