Porosity and Permeability

The geology of the injection interval is characterized based on depositional environments and subsequent controls on sand-quality distribution and implied flow geometries. EODs were determined using paleogeographic information and well log analysis of 17 wells located within the SEM boundary.

EODs were defined on a zone-by-zone basis and incorporated into the model as channel-shaped objects for the fluvial deposition within the Wilcox 1 and Wilcox 2 formations. These objects provided a way to constrain facies distribution throughout the model, where environmental controls on the deposition of clean sand and shale components could be represented. As is shown in the results of the dynamic reservoir model (Figure 2-9), a strong north-south trend occurs in the plume for injection into the fluvial EOD influenced Wilcox 2 zone.

The facies used were defined with a clay fraction (vClay) log to separate the rock into three main types: clean sand, silty sand, silt, and shale, and compared to the resulting distribution of log porosity. The final vClay ranges used to determine facies type resulted in each facies having a unique normal or skewed-normal distribution of porosity values (Figure 2-8). These porosity ranges were utilized during the porosity property modeling process.

The facies themselves were distributed in the model using log-specified proportions within each EOD (Table 2-1). Notably, the channel axis EODs in the Wilcox 1 and Wilcox 2 zones contain the highest proportions of clean sands, while the Flood Plains contain only silt and shale. The Cane River, which serves as the caprock, is comprised almost entirely of shale.

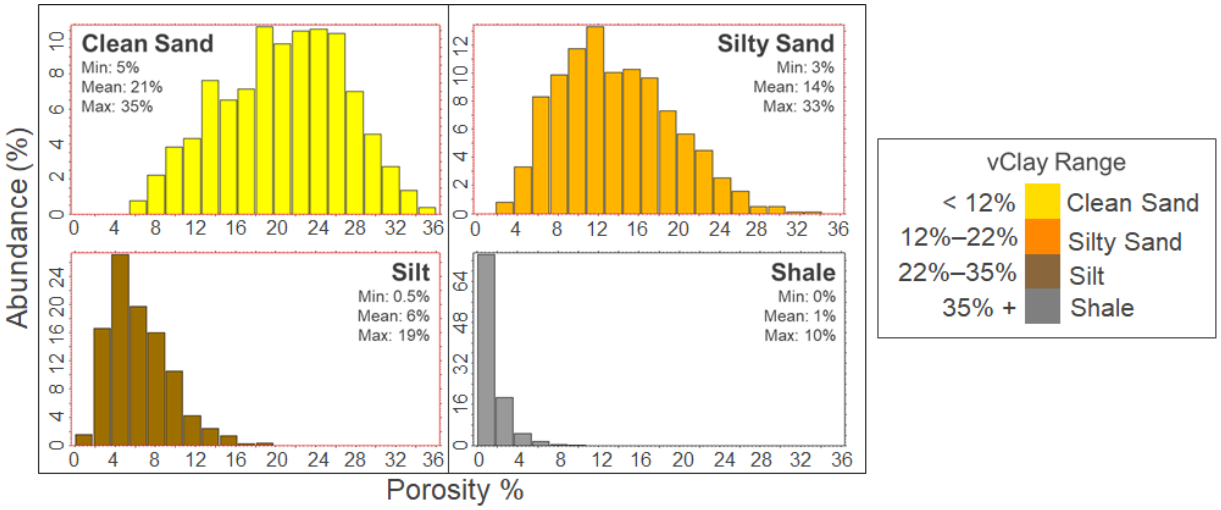

Figure 2-8: Histograms of log porosity ranges by facies type showing correlative distributions for the clean sand, silty sand, silt, and shale facies.

Facies by EOD	**Cane River** *Marine*	**Carrizo** *Marginal Marine*	**Wilcox 1** *Fluvial*			**Wilcox 2** *Fluvial*		
			Axis	***Of-Axis***	***Flood Plain***	***Axis***	***Of-Axis***	***Flood Plain***
Clean Sand	-	65	45	5	-	65	15	-
Silty Sand	-	20	30	25	-	20	20	-
Silt	5	10	15	35	20	10	30	20
Shale	95	5	10	35	80	5	35	80

Table 2-1: Proportions (percent) of each facies type assigned by zone and depositional environment.

The resulting porosity property (Figure 2-9a) was used as a direct input into the permeability property (Figure 2-9b), which was calculated in millidarcies (mD) using porosity-permeability transform functions derived from the Dutton & Loucks (2014) report on Reservoir Quality and Porosity-Permeability Trends in Onshore Wilcox Sandstones, Texas, and Louisiana Gulf Coast in the Gulf Coast Association of Geological Societies Journal. The porosity-permeability transforms are regionally derived parameters until site specific data are acquired at the STW (Figure 2-10). The porosity-permeability functions were applied based on facies type, where each facies had a unique transform.

Results of the property models matches well log data (Figure 2-11) and reflect EOD-controlled anisotropy within the Wilcox 1 and Wilcox 2 zones, with strong north-south/northeast-southwest trends. The Carrizo shows a more east-west trended anisotropy, though the interpreted depositional environment provides less control on this directionality than that of the Wilcoxes. Results of simulation for the injection well are described in detail in Section 2.2.

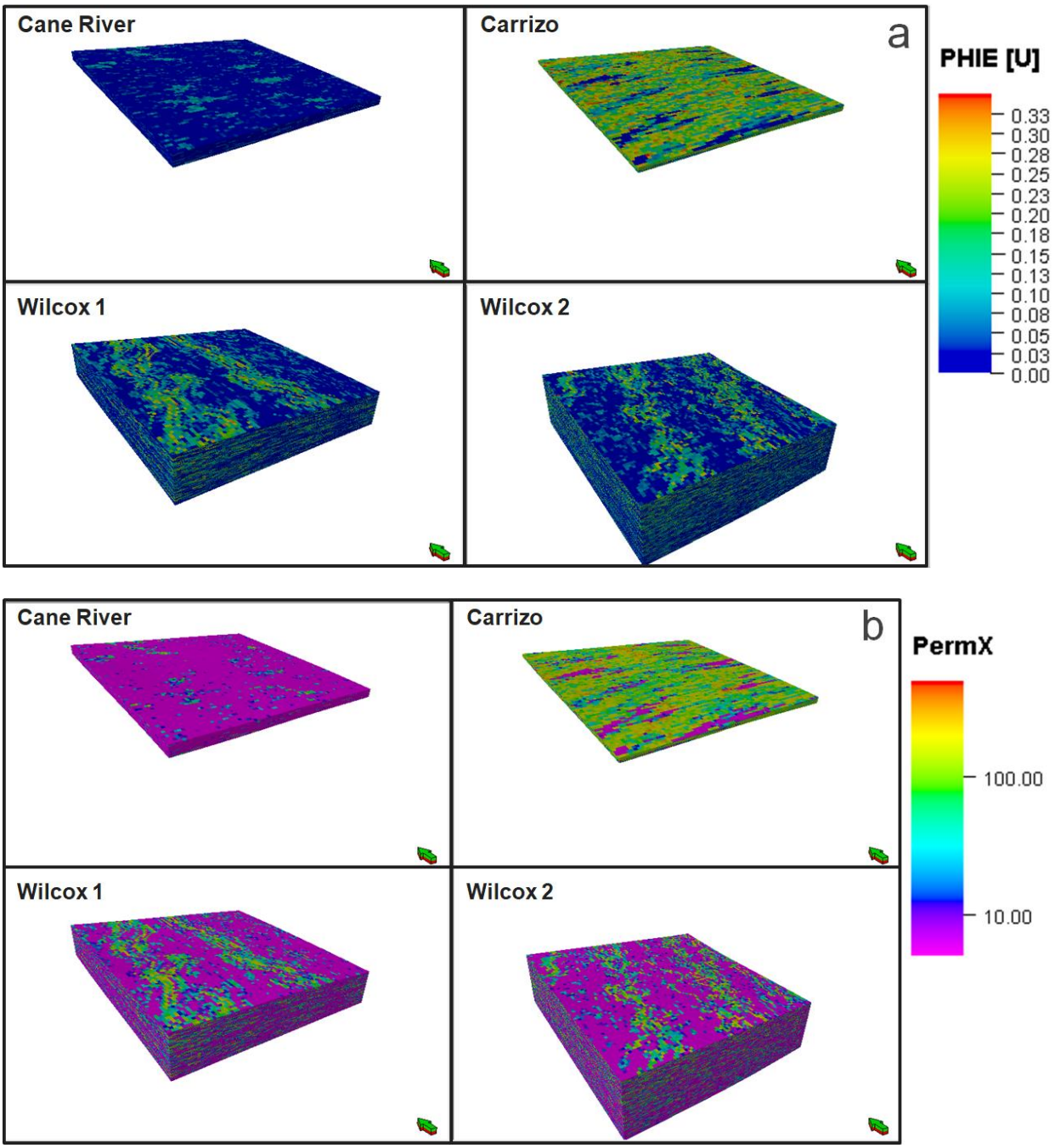

Figure 2-9: Final (a) porosity and (b) permeability properties showing the effect of depositional constraints on spatial property distribution within the 3D geocellular model.

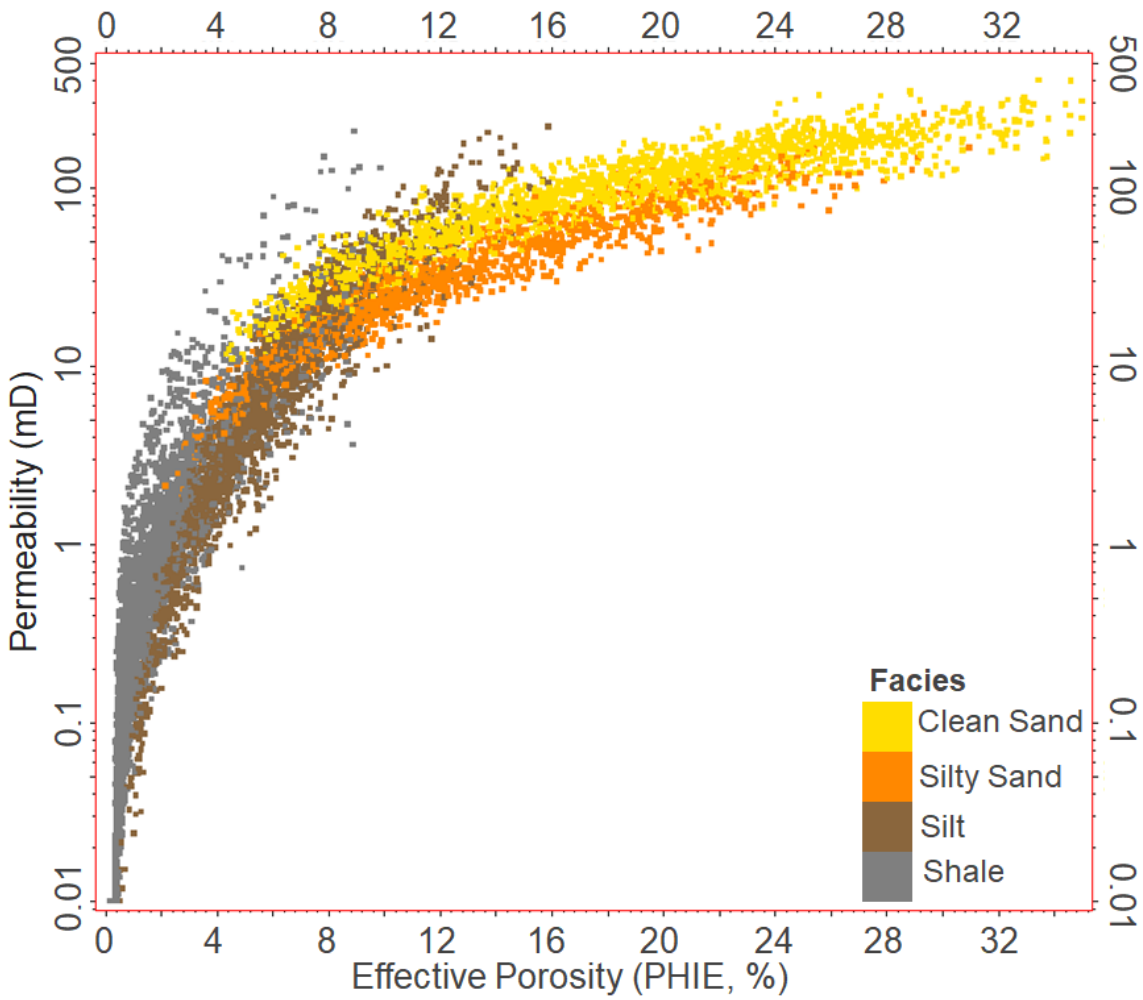

Figure 2-10: Porosity-Permeability cross-plot colored by facies showing the utilization of four different transforms applied by facies type.

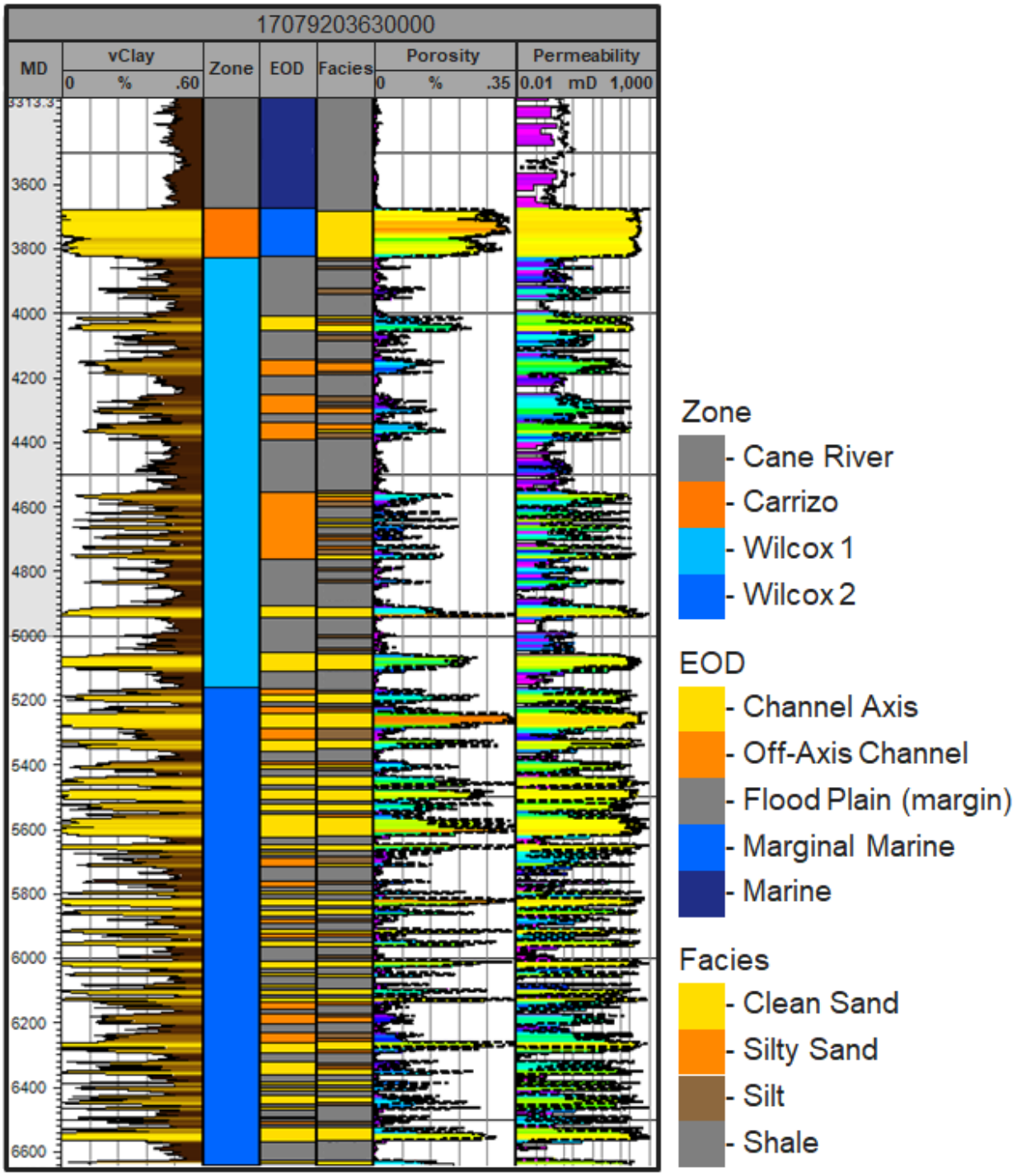

Figure 2-11: Logs at the Bentley Lumber-3 well showing (left to right) vClay, stratigraphic zone, EOD, Facies, porosity, and permeability. There is a match between the model (blocky colors) and the log (black dashed line) for upscaled porosity and calculated permeability.