Escuela Superior Politécnica del Litoral

PARES & NONES
Un break científico

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IMPACTS OF DIFFERENT OPERATION CONDITIONS AND GEOLOGICAL FORMATION CHARACTERISTICS ON CO_2 SEQUESTRATION IN CITRONELLE DOME, ALABAMA

PROBLEM STATEMENT

Massive quantities of anthropogenic carbon dioxide (CO_2) emissions from different fossil fuels have been identified as the main driving mechanism of climate change and global warming.

OBJECTIVE

Simulate CO_2 sequestration, i.e., saturation dynamics, and pressure behavior over a range of operational and geological conditions and derive conclusions about the factors influencing saturation and pressure plume size, post-injection behavior, and the risk associated with them.

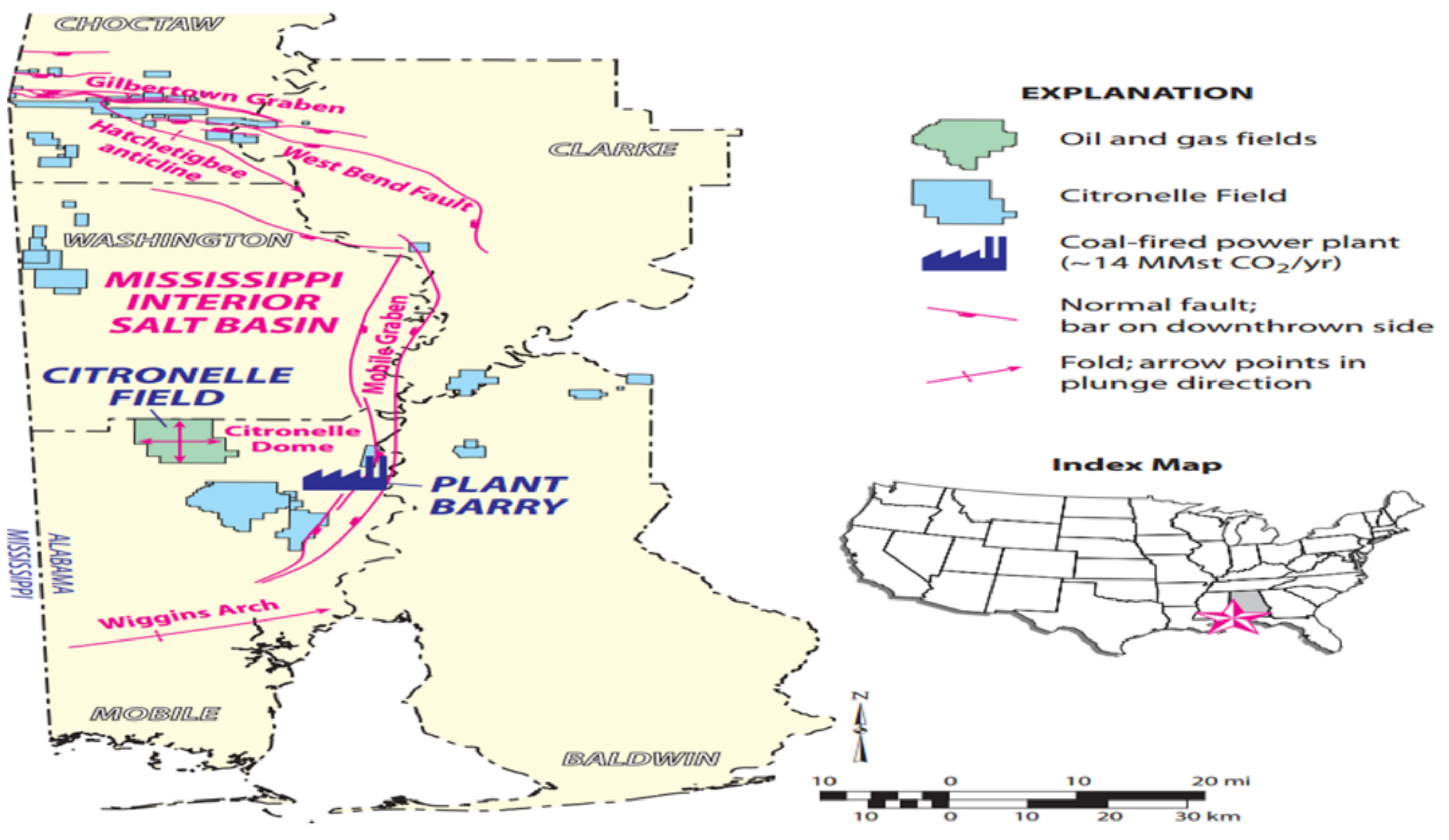


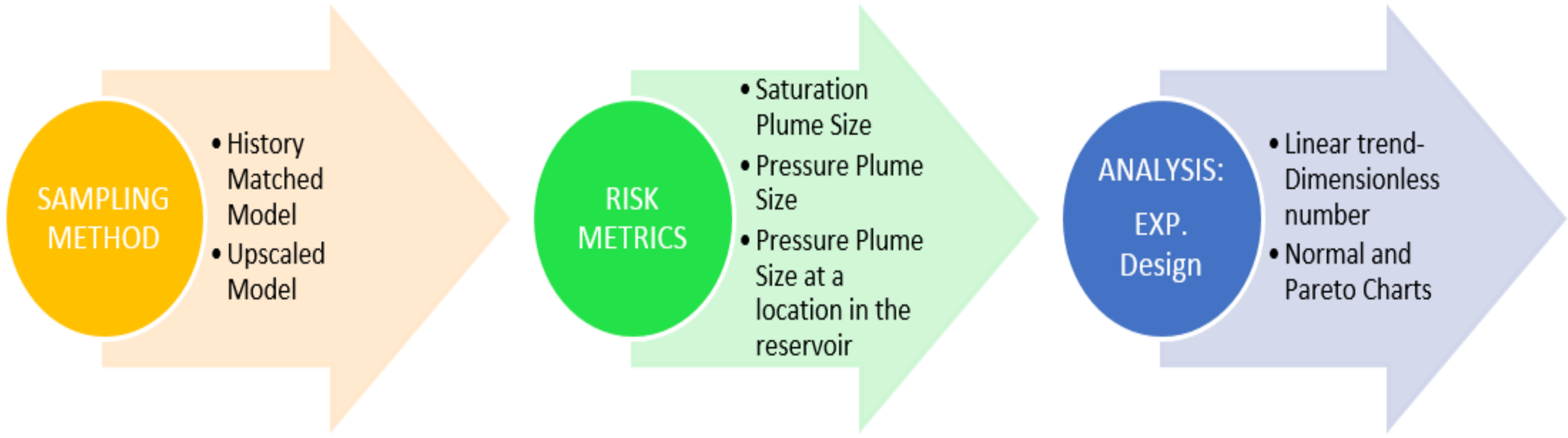
Figure 1. Location of Citronelle Field.

PROPOSAL

The Citronelle CO_2 storage project was developed in the Citronelle dome north of Mobile County, Alabama (Fig.1). To characterize the reservoir behavior over time, three main metrics were identified and quantified, including pressure differential plume area, CO_2 plume area, and pressure differential at a specific location away from the injection well (Fig 2).

Thirty-five simulations were performed using the history-matched model with closed and semi-open boundary condition. For uncertainty quantification, more than 200 simulation runs were performed for a closed and semi-open system with 3 and 30 years of CO_2 injection using the upscaled model (Table 1). Latin Hypercube Sampling (LHS) together with a Plackett–Burman design technique was used also used to assess the uncertainty.

Application of Pareto charts and respond surfaces enabled us to determine the most important parameters impacting saturation and pressure plume sizes.



SAMPLING METHOD
- History Matched Model
- Upscaled Model

RISK METRICS
- Saturation Plume Size
- Pressure Plume Size
- Pressure Plume Size at a location in the reservoir

ANALYSIS: EXP. Design
- Linear trend-Dimensionless number
- Normal and Pareto Charts

Figure 2. Methodology flowchart.

#runs	Injection Length (yr.)	Injection Rate (kt/yr.)	Post-Injection Length (yr.)	Model Domain Size (km × km)	Reservoir Thickness (m)	Permeability (md)	Porosity	Compressibility (1/psi)	Boundary Type
1	30	5000	300	5 × 5	Maps	Maps	Maps	3 × 10−6	Closed
2	3	250	50	5 × 5	Maps	Maps	Maps	1 × 10−6	Closed
3	30	5000	300	5 × 5	Maps	Maps	Maps	9 × 10−6	Closed
4	30	1000	50	5 × 5	Maps	Maps	Maps	9 × 10−6	Closed
5	3	250	300	5 × 5	Maps	Maps	Maps	3 × 10−6	Closed

Table 1. Performance metrics for H-M model.

RESULTS

Figures 3 show the CO_2 saturation distributions at the end of 3 and 30 years of CO_2 injection in the upscaled Citronelle reservoir. Different thresholds were assigned to pressure and saturation to study the CO_2 plume size and pressure area: 1, 5 and 10 bar for pressure and 0.01 and 0.2 for CO_2 saturation. Figures 4 shows the simulation response vs. dimensionless number for two cases of closed and semi-open boundary conditions. There is a clear linear trend observed when saturation plume size is plotted against the dimensionless number.

From the following Pareto charts, Figures 5, reservoir permeability and injection rate obtained had considerable influence on the pressure and saturation plume size for all the thresholds and boundary conditions.

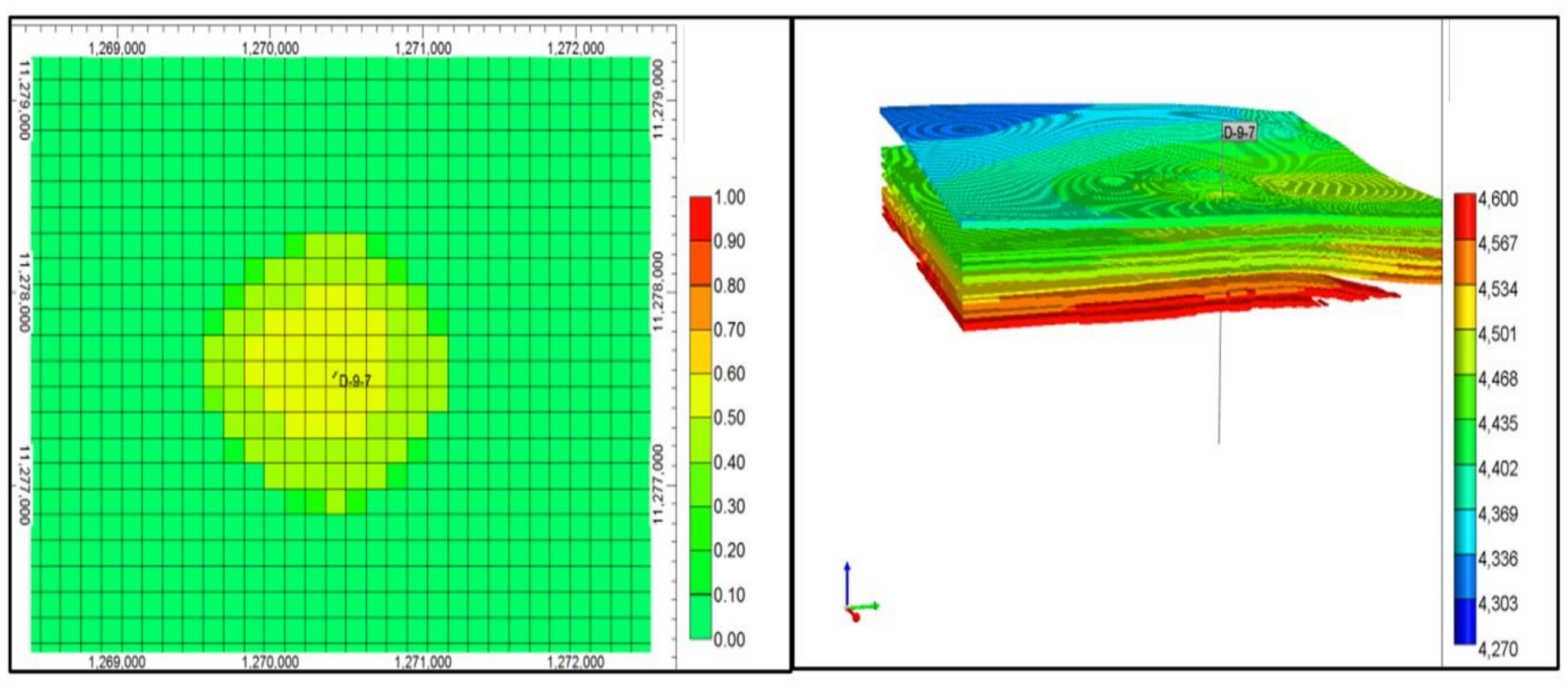


Figure 3. CO_2 saturation distribution (left) and pressure distribution (right) at the end of 3 years of injection for the history-matched model.).

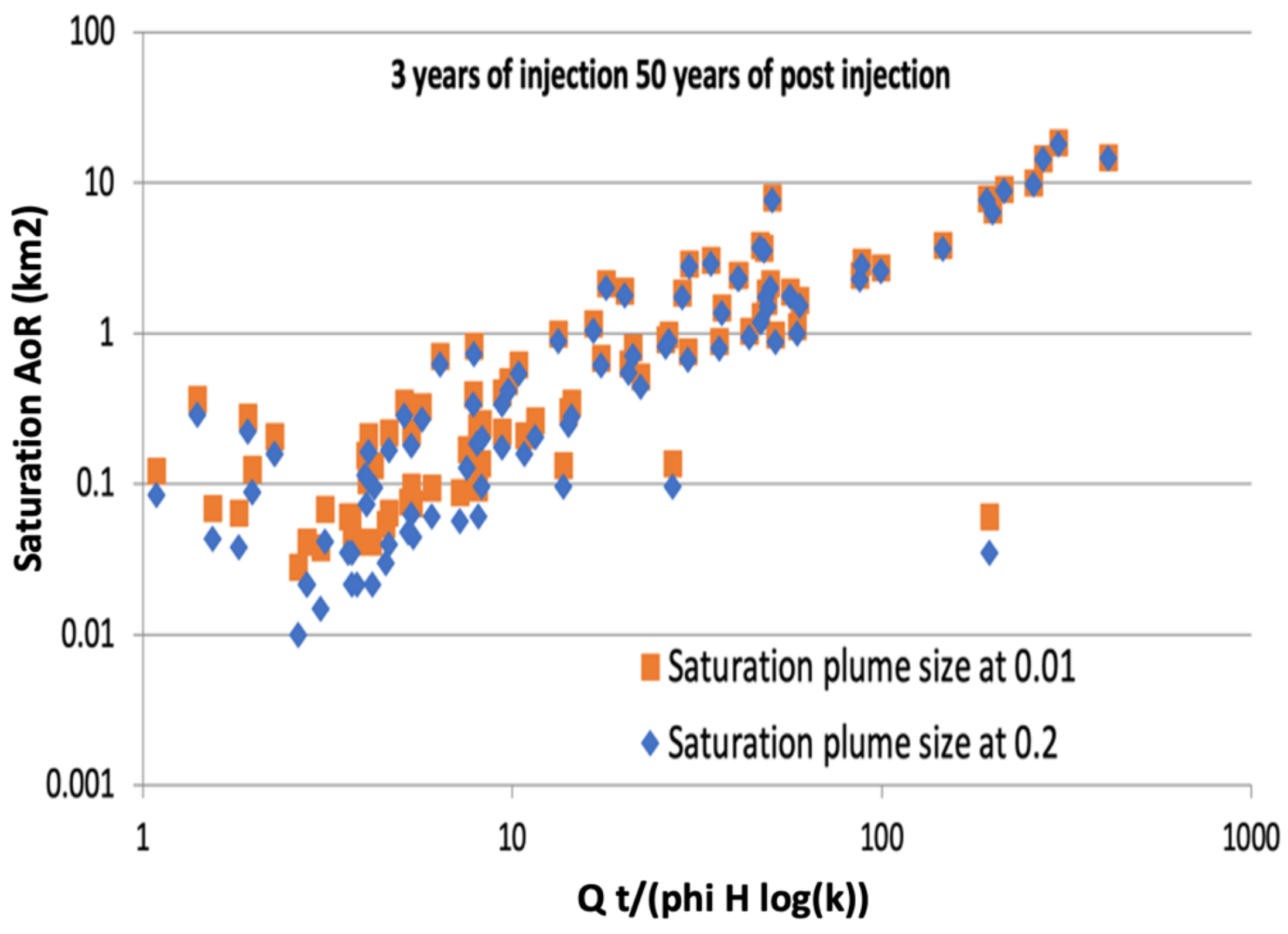


Figure 4. Saturation plume size vs. dimensionless number using upscaled model for semi-open system.

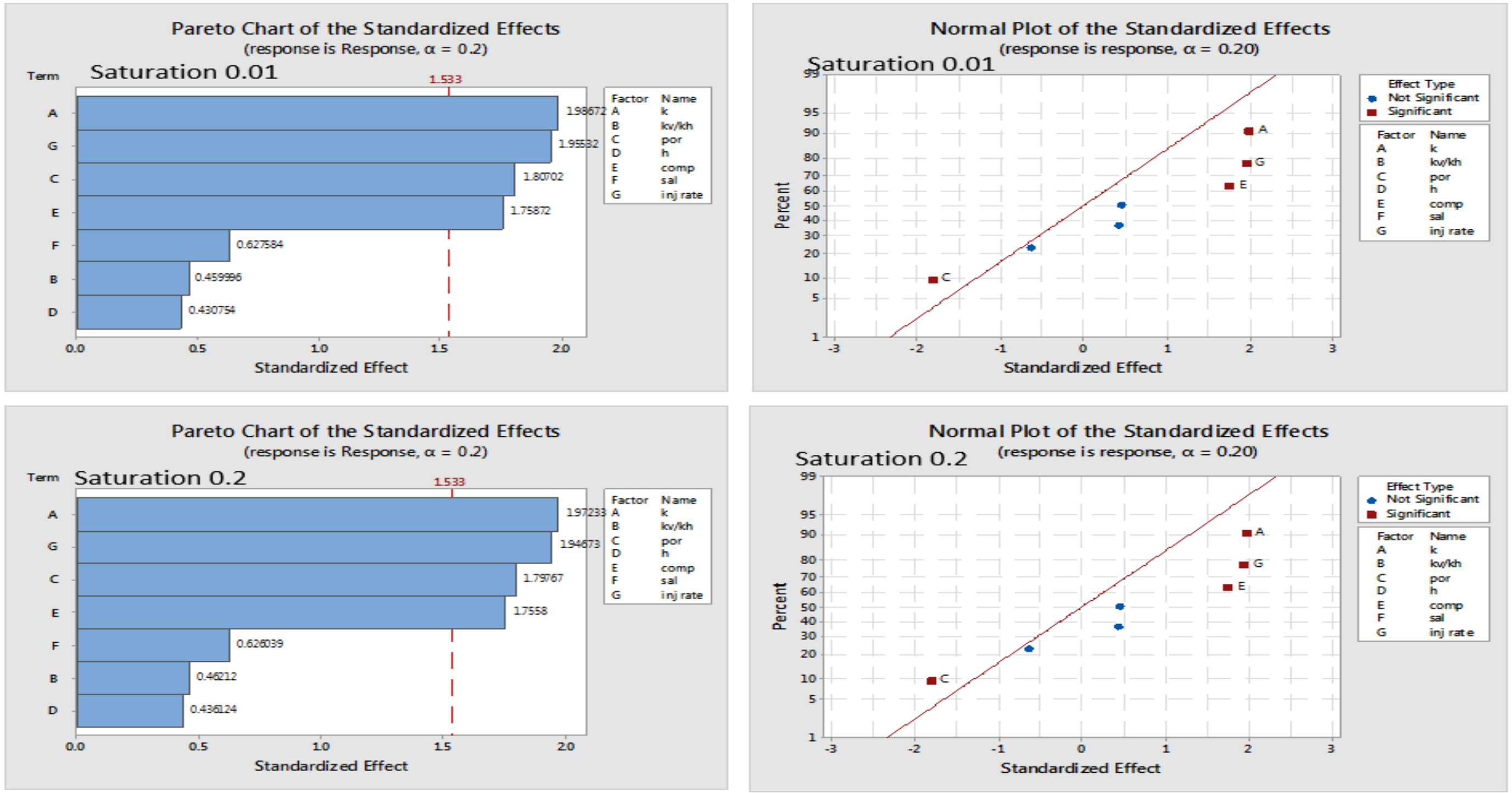


Figure 5. Pareto and Normal plot charts of upscaled model using saturation plume size for closed system.

CONCLUSIONS

- The CO_2 plume expanded during the injection period, and it stabilized in a slower growth rate after injection.
- The plume degradation stop after injection could last a few years depending on the amount of CO_2 injected and the porosity, permeability, and boundary condition of the formation.
- In open boundary cases, higher brine salinity resulted in lower CO_2 dissolution in brine and, as a result, lower impact on both saturation plume extension and differential pressure extension compared to the closed boundary condition.