Challenges to Geostatistical Mapping of Porosity and Permeability for Oil and Gas Development and Geologic Carbon Sequestration

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Computer mapping using geostatistical techniques is a routine task in reservoir characterization. However, “black box” software methods where the modeling process is hidden from the user can provide misleading results, especially when mapping porosity (matrix, for this presentation) and permeability—critical parameters for determining the feasibility of CO_2 injection projects for EOR or permanent storage—and planning for oil and gas wells. Case studies from the Appalachian and Michigan basins illustrate the difficulties in obtaining consistent geostatistical correlation between wells at multiple scales, including detailed study areas with very close spacings. In such situations maps may still be generated, but the predictions at unsampled locations are unreliable. Understanding the reasons for the lack of geostatistical correlation can lead to improvement in spatial prediction. Correlation problems can be partially explained by calibration issues between geophysical logs and porosity and permeability measurements. Calibrations can be improved by increasing the amount of geologic information used in the model (e.g., mineralogy, cementation, facies) and consideration of the statistical technique used to establish the calibrations (linear regression vs. neural networks). The complexity of the depositional environment is another important consideration. For example, a study of the Medina Group in northwestern Pennsylvania showed that porosity models for the near-shore (tidal, deltaic) Grimsby Sandstone were much noisier than that for the sublittoral sheet sands of the Whirlpool Sandstone. Rigorous geologic, geostatistical, and statistical analyses of down-hole data can help reservoir modelers evaluate the accuracy of their maps and provide potential avenues to improvement.