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Controls on the Porosity-Permeability Relationship of Limestones

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ABSTRACT

The relationship between porosity and permeability in limestones is a fundamental constitutive equation in subsurface fluid flow modeling and is essential to quantifying a range of geological processes. Porosity-permeability prediction for carbonate reservoirs is currently a challenge in the petroleum industry, largely because of the lack of publically available data and large permeability variations in some carbonates. We analyzed petrographic parameters obtained from a point-counting study to determine the primary controls on the porosity-permeability relationship and to improve the prediction of this relationship for a carbonate reservoir in eastern Saudi Arabia. The results indicate that, for a given porosity, the permeability of limestones varies over a range of up to 5 orders of magnitude. Mud content in carbonate rocks was identified to have a major control on permeability. Assessment of the individual pore types shows that both inter-particle porosity and moldic porosity contribute to the porosity-permeability relationship, while intra-particle porosity has little contribution. Multivariable regression and neural network models were then developed to relate permeability to porosity and mud content. The uncertainty in permeability prediction for a given porosity was reduced from a range of 5 orders of magnitude to 1 order of magnitude when using mud content as a quantitative texture descriptor.