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Effect of Diagenesis and Deposition on Porosity and Permeability of Sandstone: Numerical Study

We quantitatively link permeability to diagenesis in sandstone by conducting numerical pore-scale fluid-flow experiments on a CT-scanned sample. Absolute permeability is obtained from lattice-Boltzmann viscous flow simulation in the digital pore space, represented by zeros for the pores and ones for the mineral phase. The numerical results closely match measured permeability in the sample. We numerically alter the original digital sample by (a) depositing cement on the grain surface and (b) inserting small ''silt'' particles into the pore space. By calculating the permeability of the altered sandstone, we obtain permeability-porosity trends that differ depending on the diagenetic alteration process.

We explore obtaining accurate permeability estimates from 2-D images. In this approach, the 3-D digital pore space realizations are generated from digitized 2-D images via statistical indicator simulation. We produce digital 2-D images from the original 3-D digital sample by slicing it in the computer. The 2-D porosity of the slices, on average, is the same as the measured 3-D porosity.

However, the statistical spread around the average value is noticeable. It is remarkable that the calculated permeability of the statistically reconstructed 3-D realizations matches, on average, the calculated permeability of the original digital sample and also the measured permeability.

Finally, we apply diagenetic alterations to 2-D slices, statistically reconstruct the corresponding 3-D samples, and calculate their permeability. The results indicate that in clastic sediments, absolute permeability can be accurately estimated from 2-D sections.