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Application of local porosity theory and renormalization group approach to estimate permeability anisotropy of sandstone

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The renormalization group approach was applied to estimate permeability anisotropy of sandstone directly from the image sections. Each image was divided into several homogeneous isotropic cells, where the smallest cell was chosen with the help of local porosity theory concepts. The smallest cell size corresponds to the extreme value of the entropy function, which is a function of local porosity distribution. We found that the smallest cell sizes of the clean sandstones samples investigated were in the range of 100 - 300 μm.

Two point correlation functions were applied to estimate both local porosity and local specific surface area. Permeability of each smallest cell was calculated using the Carman-Kozeny formula. Larger cells were then created using a resistor network analog and applying a real space renormalization group approach after the local permeability was calculated. These cells were then rescaled upward until only one effective permeability value remained.

The results showed that the calculated permeability tended to the measured permeability as the renormalization step increased. The coefficient of anisotropy for 2-D images, defined as the ratio between maximum and minimum estimated permeability, varied from around 1.0 to 1.8. Estimation of permeability using renormalization groups was also performed for pseudo 3-D image sections created from serial sections.