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Contribution of Different Petrographically Defined Pore Types to Permeability

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The permeability of a porous medium is controlled by pore structure, in particular pore size and type, pore connectivity, and cement texture and abundance. We have extended the Carman-Kozeny type permeability model of Panda and Lake (1994, 1995) by including additional petrographic characteristics. We represent the effectiveness of secondary porosity (intragranular and grain moldic) and of visible microporosity in terms of fluid conductivity relative to intergranular porosity. Cement texture and abundance affect permeability through tortuosity and specific surface area terms.

A sample set of several hundred samples with petrographic and core analysis data was used to calibrate the model and to evaluate the model performance. Predicted permeabilities were within one order of magnitude of the measured values for more than 80% of the test samples. The model can be used to predict permeability in undrilled prospects.
The optimized model parameters indicate that the effectiveness of intragranular porosity and visible microporosity is 0.1-0.2, while the effectiveness of grain moldic porosity is 0.5-0.7.

We also present results of a parametric study using a pore network model to investigate the relationship between pore type and permeability. The network model honors the pore size distribution as well as the cement abundance and texture measured in thin-section analysis. Intragranular and grain moldic porosities have lower coordination numbers than intergranular porosity and will transport less of the bulk fluid flow. The permeability of a sandstone with 15% porosity may vary by an order of magnitude or more depending on pore type and coordination number.

Cements reduce permeability depending on abundance and texture. Both permeability models described above take into account the effect of cements in reducing permeability. As an example we show here the permeability reduction due to pore bridging cements. To investigate the reduction in conductivity with respect to the amount of pore bridging material filling the pore, numerical modeling of the fluid flow

within one pore was performed. Crystallites are randomly distributed in the pore **(**Figure 1), and conductivity is calculated for various volume fractions of pore-bridging material.

Figure 2 shows the conductivity of a pore filled with pore-bridging cement as function of the fraction of the cement. The conductivity is normalized with respect to the conductivity of an empty (open) pore. Conductivity is reduced as the fraction of pore bridging material in the pore increases, and approaches zero as the cement fraction increases to 0.7. A second-degree polynomial of the form $y=1.0 - 2.6\,x + 1.7\,x^2$ gives a good fit to the simulated conductivities. This curve describes the correction to conductivity compared with an open pore. Assuming a cement fraction of $x=0.5$, the conductivity of a pore filled with pore bridging cement is reduced to 12% of the original conductivity.

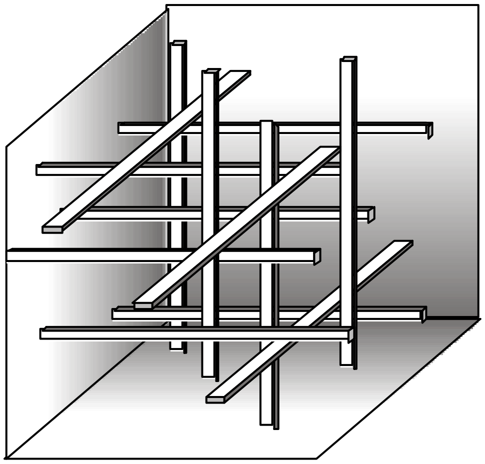

Figure 1 Schematic illustration of how pore-bridging cement crystallites may be distributed within a pore. Such a distribution provides the basis for sub-pore level network simulation that considers the effect of pore-bridging cements on pore level fluid conductivity.

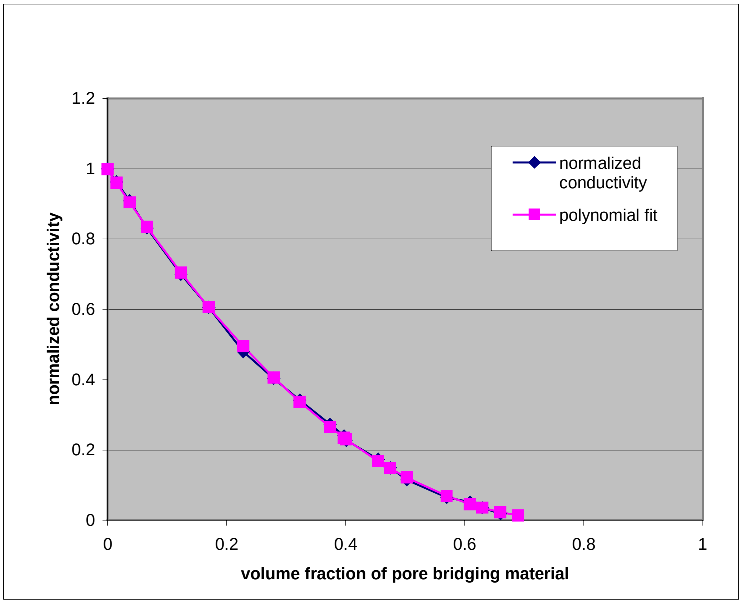

Figure 2: Conductivity of a single pore filled with pore bridging cement as function of the volume fraction of pore-bridging cement. The conductivity is normalized with respect to the conductivity of an empty pore. The polynomial $y=1.0-2.6x+1.7x^2$ is fit to the simulated conductivities.