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Modeling Stokes flow in real pore geometries derived by high resolution micro CT imaging

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Meanwhile, numerical modeling of rock properties forms an important part of modern petrophysics. Substantially, equivalent rock models are used to describe and assess specific properties and phenomena, like fluid transport or complex electrical properties. In recent years, non-destructive computed X-ray tomography got more and more important – not only to take a quick and three dimensional look into rock samples but also to get access to in-situ sample information for highly accurate modeling purposes. Due to – by now – very high resolution of the 3D CT data sets (micron- to submicron range) also very small structures and sample features – e.g. micro porosity – can be visualized and used for numerical models of very high accuracy.

Special demands even arise before numerical modeling can take place. Inappropriate filter applications (e.g. improper type of filter, wrong kernel, etc.) may lead to a significant corruption of spatial sample structure and / or even sample or void space volume. Because of these difficulties, especially small scale mineral- and pore space textures are very often lost and valuable in-situ information is erased. Segmentation of important sample features – porosity as well as rock matrix – based upon grayscale values strongly depends upon the scan quality and upon the experience of the application engineer, respectively. If the threshold for matrix-porosity separation is set too low, porosity can be quickly (and even more, due to restrictions of scanning resolution) underestimated. Contrary to this, a too high threshold over-determines porosity and small void space features as well as interfaces are changed and falsified. Image based phase separation in close combination with "conventional" analytics, as scanning electron microscopy or thin sectioning, greatly increase the reliability of this preliminary work.

For segmentation and quantification purposes, a special CT imaging and processing software (Avizo Fire) has been used. By using this tool, 3D rock data can be assessed and interpreted by petrophysical means. Furthermore, pore structures can be directly segmented and hence could be used for so called image based modeling approach. The special XLabHydro module grants a finite volume solver for the direct assessment of Stokes flow (incompressible fluid, constant dynamic viscosity, stationary conditions and laminar flow) in real pore geometries. Nevertheless, also pore network extraction and numerical modeling with standard FE or lattice Boltzmann solvers is possible. By using the achieved voxel resolution as smallest node distance, fluid flow properties can be analyzed even in very small sample structures and hence with very high accuracy, especially with interaction to bigger parts of the pore network. The so derived results in combination with a direct 3D visualization within the structures offer great new insights and understanding in range of meso- and microscopic pore space phenomena.