Quantifying porosities in sandstones: How to assess accuracy?

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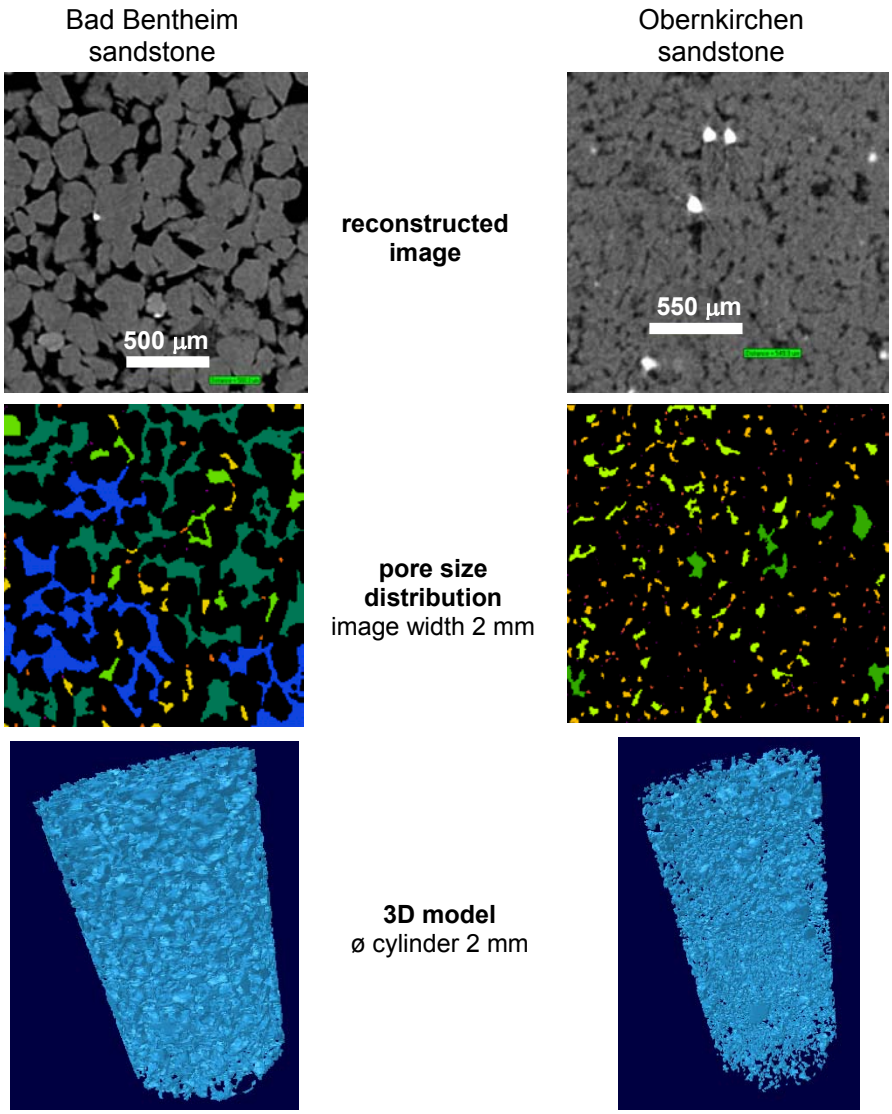
Aims. The goal of this study* is to determine effective porosity of sandstone cores and to evaluate the influence of the user-dependent parameterisation during reconstruction and segmentation. The sandstone cores are afterwards used as starting material in laboratory experiments to simulate chemical and mineralogical reactions at or near by sequestration sites of CO_2 in sandstone aquifers (Kahl et al. 2008).

Method. Aliquots of two Lower Cretaceous sandstones (localities: Bad Bentheim and Obernkirchen, both Germany), have been investigated with the SkyScan 1172 device of the experimental and theoretical petrology group at Kiel University. Fragments and cylindrical cores (with diameters of 5 mm) of both types of sandstones were studied. The medium to fine grained Bad Bentheim sandstone with a low content of dense minerals is scanned with a 0.5 mm Al filter and a beam energy of 100 keV and a flux of 100 μA, while the fine grained Obernkirchen sandstone with many dense particles is scanned with an Al/Cu foil and a beam energy of 70 keV and a flux of 142 μA. An appropriate range of attenuation coefficients and smoothing was used to reconstruct images with a range of contrast that allows the distinction of dense minerals, feldspar, quartz, and pore space by different grayscales. Subsequent to segmentation of the pore space, the sample porosities were refined using the 3D features of the SkyScan CT-analyser program.

Results. Both types of sandstone (Bad Bentheim and Obernkirchen) are well characterised in respect to their mineralogy and porosity by standard laboratory techniques. Reproducibilities of values of porosity and permeability for both types are given. Based on results of water-saturation experiments combined with Nuclear Magnetic Resonance spectroscopy, Pusch & Meyn (2001) have calculated the effective porosities of Bad Bentheim and Obernkirchen sandstones as ca. 21.5 % and ca. 12.7 %, respectively. The porosities refined by using the CT-analyser software (as percent object volume of the segmented pore space) are 22.1 % (Bad Bentheim) and 11.9 % (Obernkirchen). It is obvious that porosity values based on μ-CT data are in good agreement with experimentally derived values of effective porosities by considering typical uncertainties of porosity measurements. The μ-CT results are only slightly influenced by minor deviations of the thresholds (e.g., what might happen when segmentation is done by different users) or when comparing μ-CT data from different scanning conditions (given the images exhibit a sufficient contrast range).

Conclusions. The effective porosities of sandstone samples can be reproduced by X-ray computed tomography within remarkable accuracy. However, the successful choice of reasonable settings during the refinement process requires users with sophisticated knowledge of the investigated geological samples and also of the segmentation process. We are currently exploring the use of glass spheres with certified size distribution as standardised samples to allow less experienced users to test the quality of their refinement processing.

sandstone sample	Bad Bentheim	Obernkirchen
effective porosity in % (determined independently)	ca. 21.5	ca. 12.7
percent object volume of pore space determined by μ-CT	22.1	11.9



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