

# World record in 3d-imaging of porous rocks

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A team of physicists headed by Prof. Rudolf Hilfer at the Institute for Computational Physics (ICP) of the University of Stuttgart has established a world record in the field of three-dimensional imaging of porous materials. The scientists have generated the largest and most precise three-dimensional image of the pore structure of sandstone. The image was generated within a project of the Simulation Technology Cluster of Excellence, and contains more than 35 trillion (a number with thirteen digits) voxels. It allows now to study the relation between microstructure and physical properties of porous rocks with unprecedented accuracy. Sandstones and porous rocks are of paramount importance for applications such as enhanced oil recovery, carbon dioxide sequestration or groundwater management.

In three-dimensional imaging one discretizes spatial structures similar to digital photographs. Three-dimensional image elements are called voxels – analogous to pixels for two-dimensional digital photos. The three-dimensional ICP-images systematically resolve the microstructure of a cubic sample of Fontainebleau sandstone over three decades from submillimeter to submicron scales. The microstructure of sandstones is important for the hydraulic properties of many oil reservoirs and thus for efficient production of hydrocarbons. The largest three-dimensional image, that the physicists around Prof. Hilfer have generated, contains 32768 cubed, or 35184372088832, voxels.

For comparison: Medical magnetic resonance images of the human contain roughly 720 million voxel. Even state of the art 3d-images in science and engineering contain only up to 20 billion voxels. Expressed

in digital photos a medical image thus corresponds to only 72 photos. The largest ICP-image, however, with 35 trillion voxels amounts to a stack of 35 million such digital photographs. "This world record is important for the physics of [porous materials](#), because it allows for the first time to investigate extremely complex microstructures as a function of resolution", says Hilfer. The microstructure of a porous material determines its elastic, plastic, mechanical, electrical, magnetic, thermal, rheological and hydraulic properties. Inversely, physicists can infer information about the microstructure from measuring such physical properties.

Until now it was not possible to image a sample of several centimetres with a resolution of several hundred nanometres. "To achieve this size and accuracy would require several years of beam time at a particle accelerator such as the European Synchrotron Radiation Facility in Grenoble." explains Hilfer. His team has therefore chosen a different approach. Firstly, the scientists developed theories and methods that allow to compare and to calibrate microstructures. Then they invented algorithms and data structures that allow generating computer models of sufficient size and accuracy. These models were finally digitized and carefully calibrated against real rock samples.

Provided by University of Stuttgart

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