Geophysical Research Abstracts
Vol. 19, EGU2017-13791, 2017
EGU General Assembly 2017


# Quantifying multiscale porosity and fracture aperture distribution in granite cores using computed tomography

Quinn Wenning (1), Claudio Madonna (1), Lisa Joss (2), and Ronny Pini (2)

(1) Geological Institute, ETH Zürich, Switzerland (quinn.wenning@erdw.ethz.ch), (2) Department of Chemical Engineering, Imperial College, London, UK

Knowledge of porosity and fracture (aperture) distribution is key towards a sound description of fluid transport in low-permeability rocks. In the context of geothermal energy development, the ability to quantify the transport properties of fractures is needed to in turn quantify the rate of heat transfer, and, accordingly, to optimize the engineering design of the operation. In this context, core-flooding experiments coupled with non-invasive imaging techniques (e.g., X-Ray Computed Tomography – X-Ray CT) represent a powerful tool for making direct observations of these properties under representative geologic conditions. This study focuses on quantifying porosity and fracture aperture distribution in a fractured westerly granite core by using two recently developed experimental protocols. The latter include the use of a highly attenuating gas [Vega et al., 2014] and the application of the so-called missing CT attenuation method [Huo et al., 2016] to produce multidimensional maps of the pore space and of the fractures.

Prior to the imaging experiments, the westerly granite core (diameter: 5 cm, length: 10 cm) was thermally shocked to induce micro-fractured pore space; this was followed by the application of the so-called Brazilian method to induce a macroscopic fracture along the length of the core. The sample was then mounted in a high-pressure aluminum core-holder, exposed to a confining pressure and placed inside a medical CT scanner for imaging. An initial compressive pressure cycle was performed to remove weak asperities and reduce the hysteretic behavior of the fracture with respect to effective pressure. The CT scans were acquired at room temperature and 0.5, 5, 7, and 10 MPa effective pressure under loading and unloading conditions. During scanning the pore fluid pressure was undrained and constant, and the confining pressure was regulated at the desired pressure with a high precision pump. Highly transmissible krypton and helium gases were used as saturating fluids to obtain a sufficiently high contrast in the acquired CT images ($\sim$ 474 HU). 3D reconstructions of the sample have been prepared in terms of porosity at a maximum resolution of $(0.24\times0.24\times1)$ mm$^3$.

Porosity is estimated via the X-ray saturation technique, where porosity is a function of the difference between CT numbers of pure helium and krypton and the difference between the CT numbers of an individual voxel saturated with helium and krypton, respectively. Applying this method with krypton and helium is advantageous for low permeable samples where achieving complete water saturation is difficult. This allows for quantification of voxel-by-voxel-porosity distribution where the whole core porosity is less than 2%. The fracture aperture is assessed using the measured missing CT attenuation method. Use of the medical CT scanner to estimate intrinsic rock properties requires careful voxel-by-voxel consideration and appraisal of the uncertainty, which can be reduced by subtracting multiple slices taken at the exact same location. These results show that core-scale porosity and fracture distribution heterogeneity play an important role in fluid saturation and heat extraction potential in geothermal systems.

Huo, D., Pini, R., and Benson, S.M., 2016, A calibration-free approach for measuring fracture aperture distributions using X-ray computed tomography: Geosphere, v. 12, no. 2, p. 558–571, doi:10.1130/GES01175.1.

Vega, B., Dutta, A., and Kovscek, A.R., 2014, CT imaging of low-permeability, dual-porosity systems using high X-ray contrast gas: Transport in Porous Media, v. 101, p. 81–97, doi:10.1007/s11242-013-0232-0.