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HIGH RESOLUTION APERTURE DETERMINATIONS OF ROUGH FRACTURES IN CRYSTALLINE ROCKS

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The full characterization of the rough surfaces of fractures and the resulting variable apertures is an important step in the drive towards an improved understanding of the factors which control fluid flow through rocks. This is particularly important in igneous and metamorphic rocks, since fractures in these rocks may form the only significant pathways for fluid migration.

A number of surface profiling techniques exist, such as needle or laser profiling. However, these techniques are difficult and time consuming to apply with high resolution to the total area of a fracture because they are based upon single profiles, which are then difficult to align accurately. We have developed a new optical method for obtaining the topography of a fracture surface where the information about surface heights are measured simultaneously. The method relies on the construction of transparent high fidelity polymer models (HFPMs) of the fracture surface, which are imaged covered with dyed and undyed water. The resulting images are converted to topography by a simple calibration procedure that makes use of the Lambert-Beer Law.

The samples are a range of laboratory-fractured rocks, (i) a syenite from southern Norway, (ii) a Swedish red granite, and (iii) a medium grained, quartz-cemented sandstone from NE Scotland. In addition to profiling, the samples have been subjected to a range of petrophysical measurements to give, (i) mercury injection porosities, (ii) Hassler-sleeve gas permeabilities, (iii) grain size distributions, (iv) pore size distributions, and (v) water saturations. These samples have varying petrophysical properties, petrography and anisotropy, which control the splittability of the samples and hence their surface topography and fractal dimension. The igneous rocks split along coarse feldspar laths and the resulting surfaces are less concave and convex respectively than the sandstone. This is because the sandstone is the weakest sample due to considerably higher porosities and permeabilities than the others.

The technique works reliably, with lateral resolutions up to 15 μm, and vertical resolutions up to 15 μm. We have generated a database of fracture apertures in different lithologies, which is critical to the accurate modelling of fluids through fractures in the heterogeneous Earth's crust (see Isakov et al., oral pres., this session, for further application of these techniques).