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Complex path flows in geological media imaged by X-Ray computed tomography

Amélie Neuville (1), Marcus Ebner (2), Renaud Toussaint (3), François Renard (4,5), Daniel Koehn (6), Eirik Flekkøy (1), and Alain Cochard (3)

(1) Advanced Materials and Complex Systems group, Dep. of Physics, University of Oslo, Oslo, Norway (amelie.neuville@fys.uio.no), (2) Geological Survey of Austria, Vienna, Austria, (3) EOST-IPGS, UMR 7516, CNRS/Université de Strasbourg, France, (4) ISTerre, UMR 5275, CNRS/Université Joseph Fourier, Grenoble, France, (5) Physics of Geological Processes, Physics Department, University of Oslo, Norway, (6) School Geographical and Earth Sciences, University of Glasgow, Scotland/UK

Stylolites as well as fractures are reported as major conduits in geological media (1, 2). The flow circulation has a strong influence on hydro-mecanico-chemical processes, in particular on crystallization and dissolution (3, 4). For instance hydrothermal ore deposits are frequently located in stylolites and fractures at depth. The fluid pressure also intervenes as a thermodynamic parameter in chemical reactions, and is in addition responsible for elastic deformations of the medium. Using tridimensional numerical simulations, we aim at better characterizing the flow circulation in complex structures, and at investigating on how the flow modifies the geological medium.

First, X-Ray computed tomography scans of a complete stylolite structure (i.e. calcareous matrix, clay layering in the aperture, and the very thin aperture itself), and that of a fractured sandstone sample were performed. Then, image processing is required in order to extract the geometry of the porous medium of each sample. The geometries are actually more complicated than that of classical fractures, because of the existence of non connected – or barely connected – void spaces. We report on the influence of this image processing on the aperture geometry and on the computed permeability. This is addressed by first performing a numerical simulation of the tridimensional velocity field, using a coupled lattice Boltzmann method that solves the complete Navier-Stokes equation. After calculating the velocity field we then question the link between the geometry of complex stylolites and fractures, and the spatial auto-correlation of the velocity field. This correlation might indeed be important for dispersion processes. A first approach is to compute this correlation from the simulated velocity field. Another approach is to compute analytically the correlation function, from the knowledge of the aperture correlation. This is however developed in the perturbative limit of small aperture variations, that may not hold for the apertures found in stylolites.

We then present the pressure field obtained within these complex structures, and give preliminary tracks on how variations of the pressure might be responsible for transformations of the medium, that affect its mechanical and transport properties.

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