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Imaging crack and pore anisotropy in deformed rocks: Quantifying the crack fabric tensor

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Cracks and pores in crustal rocks are often fluid-saturated and subjected to stresses arising from both the overburden and regional tectonics. These stresses produce changes both in the shape and volume of the rock, and in the shape and volume of the voids i.e. the cracks and pores. Patterns of parallel fluid-filled cracks around major earthquake prone faults are more compliant to applied stresses compared to randomly oriented cracks and hence could produce a short-term (i.e. undrained) fluid pressure change along the fault equal to the fault normal stress, allowing the fault to slip in an earthquake [1]. Therefore, developing methodologies to quantify the orientation of pores and cracks and their mutual arrangement in deformed rocks is of primary importance to understand large active fault behaviour during earthquake cycles.

X-ray micro-CT analyses, using both intact and laboratory deformed samples, provide high-resolution (micrometre) volumetric scans from which we quantify pore and crack fabrics. Image processing provides adaptive methods to extract information from such datasets. In particular, we combine Hessian matrix filtering [2] and anisotropic wavelet analysis [3] to extract three-dimensional arrays of pores and cracks with different aspect ratios (i.e. pores and cracks) at different scales of analysis.

Observed changes in pore and crack fabrics between the intact and deformed samples allow us to characterise the multi-scale microstructural variations in anisotropy that form due to the applied stresses. In turn, the information gathered at the micro scale can be used to improve our understanding of the fundamental relationship between the theory of anisotropic poroelasticity and the measurable properties of fluid-saturated fault zones.

References:
[1] Wong, T.F., 2017. J. Geophys. Res; [2] Voorn M. et al., 2013. CaGeo; [3] Rizzo R. et al., 2018. J. Geophys. Res.