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Investigating the interplay between damage and fluid flow patterns in rocks using CT scanning imaging and acoustic emission techniques

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We present some results of an experimental study to investigate the interplay between fluid flow and the development of mechanical damage in porous rocks. Several experimental techniques were used to achieve that goal, like imaging capillary imbibition experiments by the means of an industrial X-ray CT system, damaging rock samples in low confining pressure creep tests, recording acoustic emissions to locate the damaged zones inside the rock samples, and conducting image analyses to infer relevant parameters on the physical processes involved. The selected rocks for the study are Bentheim sandstone and a limestone from a quarry in Saint-Maximin, France. Fluid flow patterns in the intact rock samples were first imaged in capillary imbibition experiments under a medical scanner. Taking one image every 1.5 seconds of a plane containing the symmetry axis of the core sample, it is possible to analyze in detail the displacement of the water front. By using image analysis tools, an automatic routine can be implemented to measure several parameters like the height and velocity of the water front, or the radius of curvature of the interface. It is shown for example that the geometry of the water front depends on the rock microstructure and that its curvature changes as the water progresses up to the top of the sample. Our results highlight also the anisotropic and heterogeneous nature of fluid flow when comparing two sets of samples cored parallel or perpendicular to the bedding plane. The samples were then deformed in a triaxial setup in creep experiments at increasing differential stress levels up to very close to the mechanical strength of the rocks. A 6-channels acoustic emission system was used to analyse the activity and to locate the damage induced during the mechanical tests. When the damaged samples are tested again in capillary imbibition experiments combined with X-ray CT imaging, it is shown that the geometry of the water front is strongly disturbed, and that this distorsion exists even far away from the localized damage. The kinetics of the water imbibition process is also significantly modified by the induced damage. Complementary data were obtained in “ reversed ” capillary tests (i.e. when water invades the sample from top to bottom) to highlight the specific influence of gravity in the imbibition process.