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Crack propagation in anisotropic material

Audrey Bonnelye (1), Hakim Gharbi (2), Alexandre Dimanov (2), Michel Bornert (3), Harsha Bhat (4), and Nathalie Conil (5)

(1) GFZ Potsdam, Germany (bonnelye@gfz-potsdam.de), (2) Ecole polytechnique, Palaiseau, France, (3) Ecole des Ponts, Marne la Vallée, France, (4) Ecole normale supérieure, Paris, France, (5) Andra, Bure, France

When cracks propagate in nature it is rarely in perfectly isotropic material, and in some cases, anisotropy can make a strong difference in terms of wave propagation or strength. For that purpose, it is crucial to study fracture propagation in anisotropic material and to address questions such as : what will be the influence of anisotropy on deformation mechanisms? On the pattern of deformation? Which parameter could be used to quantify crack propagation?

In order to try to answer these questions, we performed a set of experiments, at the microscale, aimed at deforming uniaxially samples of anisotropic shales. A hole (0.9mm) was drilled on cylindrical samples (Φ=8mm, l=16mm) with a flattened surface in order to create artificial stress concentration. Three samples were prepared with different bedding orientations with respect to the loading axis (0°, 45°, 90°). Digital images are then taken around the hole during the experiments using an optical set up with a pixel resolution of 0.55μm and a magnification factor of 10. The full strain tensor is then extracted with Digital Image Correlation (DIC) method. These experiments allowed us to see fracture initiation and propagation with different patterns depending on the bedding orientation. From our experiments we then extracted mechanical parameters such as anisotropic fracture toughness.

We also performed some calculations within the elastic domain in order to understand strain patterns by solving the problem of infinite plane under uniaxial loading with different bedding orientations assuming a transversely isotropic material.

Our study allows to understand how some complex structures that are encountered both in the lab (discontinuous fractures often seen in shales) and in natural faults (such as anastomosed faults) develop. Our understanding of the mechanisms involved are also supported by other experiments performed under SEM observations.