Characterisation of initiation and propagation of fractures in rocks using X-ray and Neutron tomography

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Abstract

Fractures affect hydrocarbon recovery in two ways: by reducing the mechanical stability of subsurface rocks and by serving as high permeability pathways for fluids to flow through them. Appropriate characterisation and accurate prediction of the initiation and propagation of fractures are essential for optimizing the design of hydrocarbon production schemes.

The open questions in rock mechanics include: where do cracks initiate in rocks? Is there a distinct entity in rock that is equivalent to dislocations in metals? Although extensive literature is available on the propagation of fractures in rocks, their initiation is less well understood. One reason why the crack initiation in rock is poorly understood compared to that in, say, metals, is the limited number of direct observations of fracture initiation and propagation under various stress states.

This project used the Neutron X-Ray Tomography (NeXT) facility at the National Institute for Standards and Technology (NIST) Center for Neutron Research (NCNR). Neutron and X-ray images of fracture initiation and propagation of chosen cores under different states of triaxial stress were acquired. First conclusion from the analysis of the Kirby (clastic sandstone from Canada with porosity in the range between 29-34%) was that the primary fracture appeared when the load was increased to 30MPa. The fracture aperture width has widened by 0.3% between the stress cases 30MPa and 40 MPa. The segmented 2D slices of the Kirby core is then compiled to create a 3D representation of the fracture distribution using volume rendering. The data sets obtained would significantly enhance the existing knowledge of fracture mechanics in rocks both through direct observations and by providing high-quality data for the development of numerical models.