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Synchrotron Quantification of 4-D Subcritical Fracture Growth During Double Torsion Experiments

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ABSTRACT

Shale and tight sand gas reservoirs possess very low permeability, and require hydraulic-fracturing to liberate gas. However, the mechanisms of fracture remain are still poorly understood. In this study, fracture propagation experiments were performed on European and American Shales and a tight sandstone using fast X-ray radiography and stepped tomography during double torsion tests. This approach directly images fracture progression from the micron to the centimetre scale, allowing quantification of crack opening displacement and other properties. Use of stereo digital image correlation on both the radiographs, and correlative high speed optical imaging, allowed the strains during fracture to be measured both through thickness (radiography) and at the surface (optical) of the samples. Moreover, the propagation of hydraulically driven fractures in shale is controlled by the interaction between the shale's microstructure and the stress fields around the tips of the propagating fracture. However, the exact form of the microstructure factors and the damage in relation to the complex grain and layer boundaries in the shale is unknown. The microstructure around fractures was therefore mapped at high resolution under a scanning electron microscope after the experiments. Using the branchline I12 at the Synchrotron Diamond Light Source (UK), this correlative imaging approach is expected to provide both new insights into how fractures propagate and highlight the microstructural factors controlling the location and the opening of fractures. Acknowledgments The following people contributed to the completion of this study: Dr Sara Nonni, Mr Sebastian Marussi, Dr Robert Atwood, Mr Matt Molteno, Dr Thorsten Becker, Pr Kevin Taylor, Dr Loic Courtois, Mr Fernando Figueroa Pilz, Dr James Marrow and Dr Michael Drakopoulos.