Geophysical Research Abstracts
Vol. 18, EGU2016-4693, 2016
EGU General Assembly 2016

Impact of ductility on hydraulic fracturing in shales

Chris MacMinn and Lucy Auton
Department of Engineering Science, University of Oxford, United Kingdom (christopher.macminn@eng.ox.ac.uk)

Hydraulic fracturing is a method for extracting natural gas and oil from low-permeability rocks such as shale via the high-pressure injection of fluid into the bulk of the rock. The goal is to initiate and propagate fractures that will provide hydraulic access deeper into the reservoir, enabling gas or oil to be collected from a larger region of the rock. Fracture is the tensile failure of a brittle material upon reaching a threshold tensile stress, but some shales have a high clay content and may yield plastically before fracturing. Plastic deformation is the shear failure of a ductile material, during which stress relaxes through irreversible rearrangements of the particles of the material. Here, we investigate the impact of the ductility of shales on hydraulic fracturing. We first consider a simple, axisymmetric model for radially outward fluid injection from a wellbore into a ductile porous rock. We use this model to show that plastic deformation greatly reduces the maximum tensile stress, and that this maximum stress does not always occur at the wellbore. We then complement these results with laboratory experiments in an analogue system, and with numerical simulations based on the discrete element method (DEM), both of which suggest that ductile failure can indeed dramatically change the resulting deformation pattern. These results imply that hydraulic fracturing may fail in ductile rocks, or that the required injection rate for fracking may be much larger than the rate predicted from models that assume purely elastic mechanical behavior.