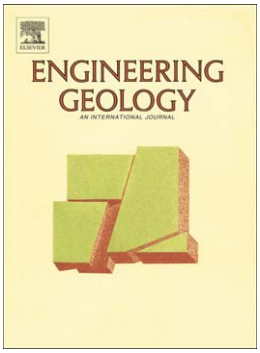

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Effects of Strain Rate on Fracture Toughness and Energy Release Rate of Gas Shales

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Abstract

The aspect of enhanced energy extraction in the field of rock mechanics requires a detailed understanding of rock fracture mechanics. Common examples are hydraulic fracturing of gas shales and geothermal energy systems. Resolving rock fracture behavioural patterns and its properties such as fracture toughness and energy-release rate during fracturing is important for the successful implementation of such scientific projects. These properties are a function of different environmental factors such as temperature, humidity, water vapour, pressure, and strain rate. In this study, the effects of various strain rates on the fracture toughness as well as the energy-release rate of gas shales were investigated. The three-point bending method was applied using notched semicircular bending shale specimens that were fabricated as per international standards. The fracture toughness and the energy-release rates were measured for three different modes, namely, mode I, mixed mode (I-II) and mode II. In addition, X-ray diffraction analysis was carried out to identify the composition of the select shales. Finally, scanning electron microscope (SEM) analyses were performed in order to acquire an insight into the effects of strain rate on fractures at microstructural scales. The experimental results indicate that the fracture toughness and the energy-release rate for all the three modes are a function of strain rates. At lower strain rates, the fracture toughness and the strain-energy-release rates for all the modes are comparable but vary significantly at higher strain rates. At high strain rates, the strength and stiffness of the shale increases, which in turn increases the fracture toughness and, eventually, the energy-release rate of the shale. For all the strain rates, mode I requires the minimum application of energy, while mode II requires maximum energy for the onset of crack growth. The energy-release rate in mode I is maximum, in comparison with the two other modes. The findings of this investigation will be useful in achieving a better and comprehensive