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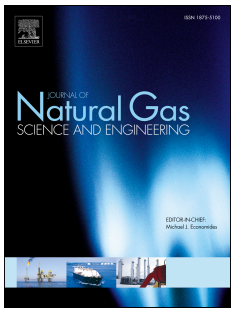

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Experimental investigation of the influence of strain rate on strength; failure attributes and mechanism of Jhiri shale

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Abstract

The modern improved engineering technologies in the field of rock mechanics and the successful identification of the hydrocarbon potential of gas shales have turned the tight shale formations as a profitable resource for the natural gas. In the current study, Jhiri shale was tested for its strength; deformational failure attributes and mechanism at different strain rates in order to understand the dependence of the deformation rate upon various geomechanical properties. The rock samples were subjected to varied strain rates during loading and the resultant geomechanical properties such as uniaxial compressive strength (UCS), tensile strength (σ_t), Young's modulus (E), failure strain (ε_f), mode I and mode II fracture toughness (K_{IC} and K_{IIC}) and brittleness index (B_1 and B_2) were determined in each case. The stress-strain behaviour of the Jhiri shale was estimated at four different strain rates that varied from 1.7 x 10^{-2} s^{-1} to 7.9 x 10^{-5} s^{-1}. It was found that all of the mechanical parameters of the rock that are mentioned above, except for the failure strain, increased with increasing strain rates. Such behaviour of the rock due to the strain rates may be due to stress redistribution during grain fracturing. At a strain rate of 7.9 x 10^{-5} s^{-1}, UCS, tensile strength, mode I fracture toughness and mode II fracture toughness of Jhiri shale were found to be 25.45 MPa, 7.71 MPa, 0.171 MPa $m^{1/2}$ and 0.083 MPa $m^{1/2}$, respectively, which increased up to 50.57 MPa, 13.06 MPa, 0.565 MPa $m^{1/2}$ and 0.467 MPa $m^{1/2}$, respectively, at a strain rate of 1.7 x 10^{-2} s^{-1}. Critical and appropriate empirical equations have been proposed to evaluate the strain-rate dependency of the mechanical properties of the rock.

Keywords: Strain rates; uniaxial compressive strength; tensile strength; fracture toughness; brittleness index

1. Introduction

After the successful exploitation of shale gas in the United States, studies on the geomechanics of shale is gaining momentum. Two key components to the success of shale gas story are directional drilling and hydraulic fracturing. The fracturing behaviour of shale under various in-situ conditions attracts the attention of scientists worldwide to resolve different critical problems in the field of geo-engineering like reservoir geomechanics, hydraulic fracturing, drilling, and blasting and geothermal