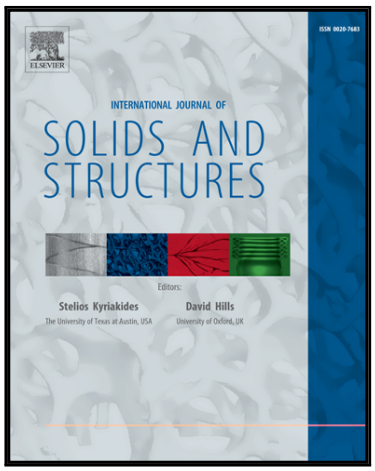

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The far-field deformation caused by a hydraulic fracture in an inhomogeneous elastic half-space

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Abstract

Elastostatic measurements of deformations by using tiltmeters located at moderate to large distances from a hydraulic fracture have often been used to map fracture geometry. The fracture is generally modeled as a quasi-static elastic dislocation, and the analytical solution for the induced deformation by the dislocation in a homogeneous elastic material is commonly used as a forward model to map the fracture geometry by fitting the deformation measurements. However, the mechanical properties of the reservoir in which a hydraulic fracture is placed are often very different from those of the surrounding rocks. In order to obtain a correct interpretation of the created fracture geometry, the mechanical property contrasts need to be recognized and taken into account.

In this paper, a mechanical model is presented and applied to the problem of calculating the far-field deformation and stresses induced by a fracture in a reservoir with mechanical properties different from those of the otherwise homogeneous elastic half-space. The fracture is modeled as a constant displacement discontinuity over the fracture plane, and the corresponding eigenstrain associated with the fracture is defined based on the geometries of the fracture and reservoir. Analytical expressions connecting the induced far-field deformation and stresses with the geometrical and mechanical properties of the inhomogeneous system have been established based on the equivalent inclusion method. The proposed model offers a simple and computationally efficient method to account for the effect of inhomogeneous mechanical properties on the far-field deformation induced by the fracture, which can then be used to undertake tiltmeter mapping of the fracture geometry. The mechanical model is verified by comparing with finite element results and analytical solutions available in the literature.