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亀裂地盤内の孔隙水圧変化による応力集中の研究
Stress concentration in fractured medium due to formation pressure changes

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Hydraulic fracturing technique has been used for obtaining the magnitude and direction of the horizontal in-situ stress field in the subsurface. Recently, this technique is applied to develop new types of hydrocarbon reservoirs, i.e. unconventional resources such as shale oil or gas. It is important to understand the generation and propagation of fracturing under three-dimensional stress conditions since these resources require hydrofracturing through drilled holes.

However, we do not have much information on the stress distributions and pre-existing fractures around the borehole in many cases. Furthermore, the propagation direction of fracturing in heterogeneous rocks with fractures is not well understood.

In the present study, we introduced a numerical simulation based on the extended FEM (X-FEM) to deal with the pre-existing fractures. The utilization of X-FEM allows us to consider various fracture parameters (stress intensity, J integral evaluation, etc.) and to deal with the propagation of pre-existing fractures.

Our results under various stress conditions and pre-existing cracks show that the points of stress concentration around the borehole do not match the orientation of the maximum principal stresses because of pre-existing fractures. Our results also indicate that in-situ stress and pre-existing fractures have an effect on the hydraulic fracturing test using borehole breakout and drilling induced fracturing. The propagation of pre-existing fractures could be induced by injection pressure. As a consequence, the orientation of fracture propagation converged to that of maximum principal stresses. The convergence speed depends on injection pressure. The higher injection pressure is added, the stronger tendency to propagate straight fracture propagation is indicated. We would like to conclude that our numerical simulation has revealed the stress distribution around borehole in rocks including pre-existing fractures has a tendency for fractures to propagate in a direction to the maximum principal stresses.

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