THE EFFECT OF DISCONTINUITIES ON THE GEOMECHANICAL RESPONSE OF CARBONATE RESERVOIRS

Ahmad Zareidarmiyan[1], Hossein Salarirad[2], and Victor Vilarrasa[3]

Long Abstract

Fluid injection and/or extraction in natural or engineered reservoirs as a part of geo-energy application, e.g., improved oil recovery, geologic carbon storage, and geothermal energy, involve geomechanical challenges that require further understanding. Improved oil recovery methods imply the injection of fluids that induce pressure and temperature changes in the reservoir. These changes cause a geomechanical response of the subsurface that may compromise reservoir stability and caprock integrity. Most of the world's oil and gas are borne in carbonate reservoirs, which are commonly fractured. Accordingly, the geomechanical response of these reservoirs and their caprocks to injection and production operations is controlled by pre-existing fractures. However, considering the complexity of including fractures in numerical models, they are usually neglected and incorporated into an equivalent porous media as a simplification. Thus, the effect of fractures on fluid flow and geomechanical responses is generally neglected, which may be an unreasonable assumption in some cases, like in carbonate oil reservoirs. Coupled thermo-hydro-mechanical (THM) processes in fractured geological media entail complex interactions between the fluid pressure, temperature, and stresses changes. Simulation of these coupled THM processes in fractured reservoirs requires numerical simulators that solve all the processes in a fully coupled approach or a sequential approach in which a fluid flow code is coupled to a geomechanical code. In this paper, we perform THM numerical simulations of fluid injection and production into a naturally fractured carbonate reservoir for one year. Simulation results show that fluid pressure propagates much faster through the fractures than the reservoir blocks as a consequence of the permeability contrast between the reservoir blocks and fractures. In spite of that, pressure diffusion propagates through the reservoir blocks, reaching equilibrium with the fluid pressure in the fractures within days. Yet, the cooling front moves forward much faster through the fractures by advection than the reservoir blocks by conduction. Therefore, cooling mainly remains within the fractures. Additionally, the total stresses change as a result of pressure and temperature changes, both in the fractures and the matrix blocks. The maximum change within fractures occurs along the longitudinal direction and the minimum in the normal direction of the fractures. We recognize that shear failure is more probable to happen in the fractures and reservoir blocks that undergo cooling and pressure changes than when only pressure

1- PhD candidate of Rock Mechanics, Department of Mining and Metallurgical Engineering, Amirkabir University of Technology-Tehran Polytechnic (AUT), Tehran, Iran.

2- Assistant professor, Department of Mining and Metallurgical Engineering, Amirkabir University of Technology-Tehran Polytechnic (AUT), Tehran, Iran.

3- Senior Researcher, Institute of Environmental Assessment and Water Research (IDAEA), Spanish National Research Council (CSIC), and Associated Unit: Hydrogeology Group UPC-CSIC, Barcelona, Spain.

changes occur. It has also been observed that the caprock integrity is maintained as the stability changes in the caprock are small. It is concluded that including fractures explicitly into numerical models permits identifying fracture instability that may be otherwise ignored.

Keywords: fractured reservoirs; thermo-hydro-mechanical (THM) analysis; geomechanical response; caprock integrity; cooling.