Effects of CO_2 Associated with Natural Gas Generation on Local Porosity Generation in Carbonate Formations

Peng Lu, Pan Luo

Saudi Aramco

Abstract

In the literature, it is still controversial whether or not carbonate dissolution by CO_2 associated with natural gas generation will significantly increase the overall porosity of carbonate formations in a diagenetic environment. Reactive transport modeling (RTM) was conducted on a generic numerical charging model of natural gas rich in CO_2 for a carbonate formation. The model includes coupled gas-water-rock interactions, multiphase flow, and spatial heterogeneities of the geochemical reactions. The models are 2D with only vertical variation and the simulation time is 20 Ma. The following questions are explored: (1) Can CO_2 redistribute/modify the formation porosity at a large scale? (2) How does the dissolved material migrate? (3) What is the extent of local porosity change? (4) What is the effect of regional groundwater on the porosity redistribution? The simulation results indicate that CO_2 can induce dissolution and porosity increase locally, which occurs mainly in the vicinity of gas-water-contact (GWC) for the configuration of this study, instead of the entire formation. After regional groundwater migrates across the GWC, groundwater is acidified by the CO_2 (g) in the gas zone, and thus will dissolve carbonate minerals to form secondary porosity. Our results indicate that secondary porosity generated due to local dissolution is ~0.04 (volume fraction of total rock), with a maximum value of ~0.27. The dissolved minerals are transported out by the groundwater flow. For localized dissolution, it only requires a small flux of CO_2 and groundwater to take effect. The limited CO_2 from source rock and groundwater flow in the subsurface seem to be sufficient to support local secondary porosity generation. Purification of natural gas by consumption of CO_2 component, a process commonly being overlooked, can happen during the charging and preservation processes. This modeling study provides a quantitatively assessment on the impact of diagenesis on reservoir quality and hydrocarbon quality in the studied simulations.