TitleFrom Pores to Production – Modeling the Combined Flow Behavior in Organic and Mineral Hosted Porosity Systems

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Summary

The unconventional source rocks consist of multiple porosity types: organic, mineral, and a combination of the two. Flow observed at the well level is a summation of influxes from billions of these diverse pores. Using density functional hydrodynamics implemented in the Direct HydroDynamic (DHD) simulator, we previously modeled fluid flow only from organic pore spaces. We continue our study to expand our understanding beyond just organic pores and have modeled flow through organic, mineral, and fracture porosity, as well as a combination of all three pore types. The DHD simulator performs direct numerical simulations of multiphase transport with allowances for phase transitions and nanoscale phenomena. The simulator was used to model gas expulsion drive occurring in the organic pores and to calculate theoretical recovery. The DHD simulator was also used to gain insight into enhanced oil recovery (EOR) scenarios by investigating the behavior of organic pore systems during gas injection. Simulations showed good uplift in recovery due to gas injection. The effectiveness of the EOR injectant, is a function of the in-situ oil. In cyclic gas injection (huff-n-puff), oil release increases as the number of injection production cycles increases. The theoretical maximum EOR recovery approaches 30% for well-constructed injection scenarios. Expanding the organic pore studies to include the interaction with mineral and combined pores provides insight into the dynamic behavior of source rocks. We now are able to demonstrate the connection between various porosity types and the dynamic fluid flow behavior as a function of pore pressure. The outcome of the simulation represents dynamical hydrocarbon release data (including release rate of chemical components of studied fluid) and gas/oil ratio (GOR) data as a function of pore pressure. It shows dynamical flow behavior within the source rock during initial and EOR production, and provides insight on the pore-scale mechanisms that are affecting release. Predicting unconventional well performance is problematic. In decline curve analysis (DCA), a changing “b” factor with production is a commonplace. In rate transient analysis (RTA), multiple models are often needed to match early and late time performance: the tale of two wells. The GOR behavior is anything but conventional. DHD simulation data provides insight into understanding these production mechanisms and can serve as the basis for laboratory experimentation.