

Chemical and Mechanical Alterations of Caney Shale during Core-Flooding Experiments with Field-based Fracturing and Produced Fluids

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Abstract

Exploitation of hydrocarbons from unconventional shale reservoirs is critical to meeting the ever-increasing demand for energy. To exploit these resources, shale reservoirs require stimulation, mainly by hydraulic fracturing, to increase permeability and facilitate the flow. This involves the injection of large volumes of water-based fracturing fluids into the subsurface which may react with the formation to cause long-term reservoir damage. To prevent this problem, it is imperative to understand the subsurface geochemical rock-fluid reactions in shales and how they adversely alter the mechanical and petrophysical properties of the formations.

This study employs dynamic core flooding experiments using both fracturing fluids and produced fluids injected in specific order to replicate reactions during and after hydraulic fracturing. Core-plugs of 1-in diameter and 2-in length were drilled out from 4-in diameter core recovered from Caney Shale of southern Oklahoma. Core flooding experiments were conducted at temperatures of 95°C, pore pressure of 4000psi and confining pressure of 4500psi. Effluent sampling was undertaken on days 1, 4, 7, 14, and 21. Sample parameters were measured pre-experiment and post-experiment to enable evaluation of changes that occurred due to rock-fluid reactions. X-ray Fluorescence (XRF), Raman Spectroscopy and Rebound Hardness Tests (RBH) were respectively used to assess the rock cores' chemical, mineral, and mechanical properties before and after experiment. Elemental analyses of fracturing and produced fluids, and effluents were conducted using Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). The results from these tools were subsequently integrated to provide comprehensive understanding of geochemical changes that result from interactions between rocks and injected fluids.

Preliminary results show transformation of chemical compositions on core-rock surfaces that confirms considerable reaction between rock and fluids. Reduction of concentrations of elemental species such as Si, Ca, Mg, Fe, Na, K, and Al point to the dissolution of minerals such as calcite, dolomite, pyrite, feldspar, and quartz. Coupled with this, the rebound hardness of the samples witnessed a significant decline which confirms the dissolution of brittle minerals on the rock surface. Finally, elemental concentrations from ICP-MS measurements showed significant disparity between initial fluids and effluents collected after reacting with rock under high temperature and pressure. Most findings from effluent analyses corroborate the findings from other evaluation methods.

This work gives an insight into rock-fluid reactions along fracture walls in hydraulically fractured reservoirs of the Caney Shale in southern Oklahoma. It highlights the alterations on fracture face during rock-fluid reactions and the impact of these on petrophysical and mechanical properties. This provides an understanding of the impact of geochemical rock-fluid interactions during and after hydraulic fracturing and provides a basis from which adverse reactions could be mitigated.