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Subsurface Geochemical Rock-Fluid Reaction in Caney Shale of Southern Oklahoma

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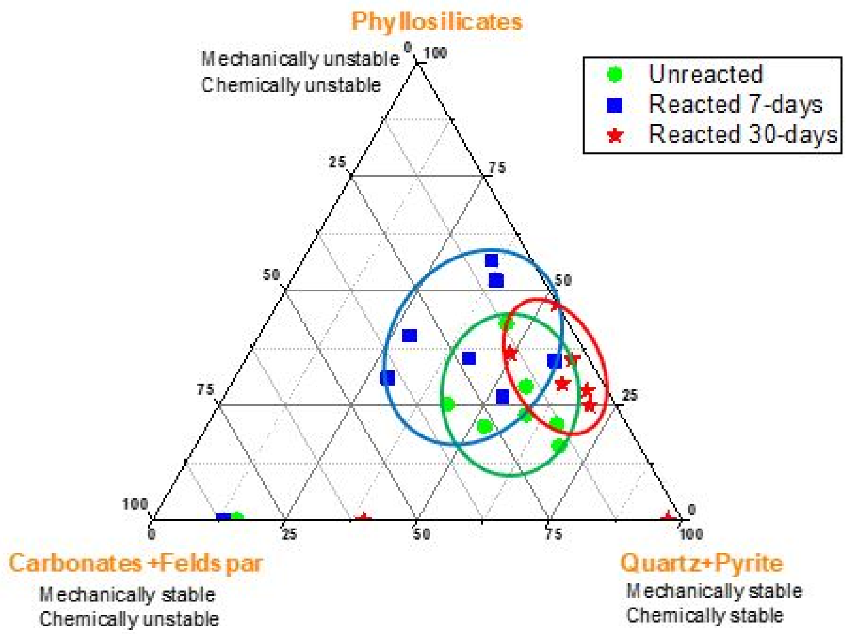
Abstract Text:
Production rate in hydraulically fractured reservoirs is expected to decline with time linearly in log-log space, with a slope of -1/2. However, most hydraulically fractured reservoirs witness a faster decline after 2 to 5 years of production, indicating a loss of permeability. Several studies have tried to diagnose the predominant mechanism driving this loss, but the findings remain divergent between geo-mechanical stress dynamics or geochemical rock-fluid reactions. This study evaluates the causes of permeability decline from the perspective of geochemical rock-fluid reactions considering their pervasive nature, which allows them impact even the smallest pores within reservoirs.

This study employs static batch reactor experiments using rock powders, field fracturing fluids and produced fluids, while deionized water is used as a control. Sample parameters are evaluated before and after reactions using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and inductively coupled plasma mass spectroscopy (ICP-MS). The results are integrated to characterize the geochemical changes due to rock-fluid reactions. Experiments are subsequently modeled to understand the long-term trends of reactions as well as their potential products and impact on permeability of the formation.

Preliminary results show mineralogic and elemental transformations in rock powders reacted with both fracturing and produced fluids.

Dissolution of pyrite and feldspar and increased illite composition are evident in both sets of experiments, while dissolution of carbonate minerals is more pronounced in fracturing fluids. Elemental concentrations in effluent also showed significant disparities from initial fluid compositions. Modeling corroborated the mineralogical and elemental changes observed from the laboratory evaluations.

This study provides insight on the impacts of adverse geochemical rock-fluid reactions on permeability losses in hydraulically fractured reservoirs. The increased illite composition tends to shift reservoir rock characteristics from brittle to ductile and thus facilitates the rapid permeability loss. This knowledge will therefore serve as input in fine-tuning fracturing fluid compositions to mitigate long term permeability losses.



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