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Why fractures in Marcellus Shale might be plugged too soon: Case study comparing geochemical and geomechanical data obtained from outcrop vs reservoir cores

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Shale rocks play an essential role in petroleum exploration and production because they can occur either as caprocks for subsurface storage in conventional reservoirs or as unconventional reservoir rocks for hydrocarbon extraction via hydraulic fracturing. The ability to produce gas from rocks previously only considered caprocks is an unprecedented and innovative feat, but does not come without an environmental impact and costly issues with permeability reduction of engineered fracture systems. The quantities of water required for hydraulic fracturing and developing these formations for production have been large, and the amounts of flowback and produced water after the hydraulic fracturing processes have been astronomical. These volumes make it imperative that a water recycling solution be found and applied to the development of these fields.

In this study, a batch reaction was conducted with Marcellus shale. Both outcrop and reservoir cores (from different points along wellbore trajectory) were exposed to de-ionized water and a synthetic hydraulic fracturing mixture at reservoir temperature for up to four weeks at a high fluid to rock volume ratio. The chemistry of the created simulated flowback and produced water were analyzed using an ICP. In addition, microstructural analyses were performed in order to establish mineralogical and structural properties, as well as presence of microfractures. Furthermore, indentation tests were conducted at both micro and nanometer level to link the geochemistry and geomechanics of shale rocks, through mechanical properties mapping, the volumetric proportions of each phase can be estimated based on the differential mechanical properties.

The key findings include an analysis of the variation of the simulated flowback water from surface down to cores at a depth of 6420ft, with a focus on heavier mineralogical elements and metals. Less than 1% of the fluid used in these tests consisted of hydraulic fracturing fluid additives, however, even with this small volume of additives used, a significant difference in mineral dissolution compared to the samples treated with water only was observed. The carbonates in the rock samples showed a high level of dissolution, which can cause an increase in permeability, but can also precipitate causing fracture bridging as well as scale buildup in wellbore structure/pipes. The concentration of Pb was found to be significant in the water comparison, posing a potential environmental issue. The indentation results showed a significant difference in mechanical properties as the result of the alteration in microstructures and mineralogical composition during the batch reaction, and the change of microstructure causing by dissolution/precipitation of individual phase were correlated with the alteration in bulk response of the rock.These findings are preliminary and would require and extensive study that would include numerous samples for different location within Marcellus Shale as well comparison to other producing shale formations.

References

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