Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.12603

Subsurface Engineering of Conductive Fractures in Caney Shale, Southern Oklahoma: A Step Towards Energy Transition

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The Caney Shale is an emerging unconventional hydrocarbon resource in southern Oklahoma that contains a strong oil and natural gas drive. To produce hydrocarbon from low permeability rocks, a network of hydraulic fractures is engineered via large volume, high pressure injection of sand rich brines. However, development has been hampered largely because the unknown geomechanical properties of clay-rich ductile shales can limit the fracturing of such formations. My research is focused on the mechanism of proppant embedment into fracture walls that leads to fracture closure and reduction in permeability, so that hydraulic fracturing fluids that enhance hydrocarbon production from Caney Shale can be developed.

Firstly, the samples were prepared by extracting eight plates (7x2x0.5inches) from a drilled 4-inch Caney core (Figure 1a), with each four-plate set from a ductile and reservoir (brittle) region, respectively. These plates were then used to sandwich a proppant sand pack and loaded at high-temperature and high-pressure to mimic fracture behavior under reservoir conditions of 210°F and 2,000 to 12,000 psi, measuring the fracture permeability over six weeks. This created proppant embedment craters that were further analyzed using various techniques, including a Leica DVM6 Digital Microscope utilizing Las X software to generate 3D scans, topography maps, and line profiles to quantitatively analyze the degree of proppant embedment (Figure 1b).

Results showed obvious proppant embedment along the surfaces of shale plates under high pressure. However, when the fracture closure pressure declined from 12,000 to 4,000 psi, the fracture permeability in the ductile region was increased, while the brittle regions remained unchanged. This could have an implication on refracturing as a secondary attempt for enhanced fracture permeability.

The findings in this study first and foremost will contribute to safe, economic, and responsible producing of the Caney Shale. On a fundamental level, the project will contribute to the understanding of Ductile Shales for a variety of applications, from hydraulic fracturing and carbon and hydrogen subsurface storage to the potential contribution of shales to plugging and abandonment.

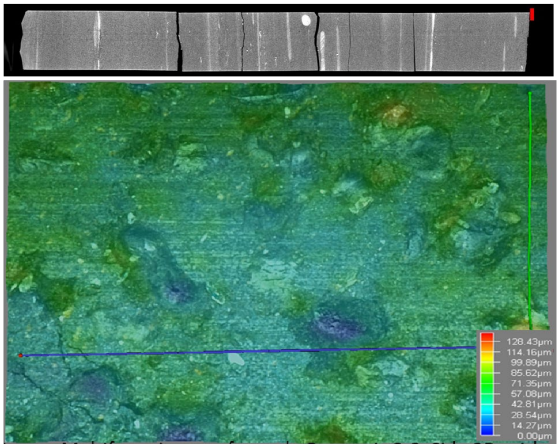

Figure 1: a) Top image is CT image of the 4-inch-wide drilled core from Caney formation, b) Bottom image is a 3D optical scan with a topographical overlay of shale rock surface with proppant embedment marks shown in dark green/deep blue, showing microscale features.