MONTANA STATE UNIVERSITY
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Civil Engineering

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Plant Biosciences Building 108 and via Webex

Comparing the Mechanical Properties of Shale Cores: Intact vs Fractured and Sealed with UICP

Abstract: Fractures in subsurface shale formations are instrumental in the recovery of hydrocarbon resources. A byproduct of hydraulic fracturing, these fractures have the potential to become harmful leakage pathways that may contribute undesired fluids to the atmosphere and functional groundwater aquifers. Ureolysis-induced calcium carbonate precipitation (UICP) is a promising biomineral solution where the urease enzyme converts urea and calcium into calcium carbonate mineral. The resulting biomineral can bridge gaps in fractured shale, reduce undesired fluid flow through leakage pathways, limit fracture propagation, better store carbon dioxide, and extend the efficiency of future and existing wells. The mechanical properties of fractured shale sealed with UICP was investigated using a modified Brazilian indirect tensile strength test. Part one of this study investigated the tensile strength of shale rock using intact Eagle Ford (EF) and Wolfcamp (WC) shale cores (5.08 cm long by 2.54 cm diameter) tested at room temperature (RT) and 60°C. Results show no significant difference between shale types (average tensile strength = 6.19 MPa). EF cores displayed a higher strength at RT versus 60°C, but no difference was seen between temperatures for WC cores. Part two sealed shale cores (5.08 cm long by 2.54 cm diameter) with a single, heterogeneous fracture spanning the core length. UICP was delivered two ways: 1) the flow-through method injected 20-30 sequential patterns of microbes and UICP-promoting fluids into the fracture until fracture permeability reduced by 3 orders of magnitude and 2) the immersion method placed cores treated with guar gum and UICP-promoting solutions into a batch reactor, demonstrating that guar gum is a suitable inclusion to UICP-technology and may be capable of reducing the number of injections required in flow-through methodology. Tensile results for both flow-through and immersion methods were widely variable (0.15 – 8 MPa), and in some cores the biomineralized fractured split apart. Notably in other cores the biomineralized fractured remained intact, demonstrating more cohesion than the surrounding shale, indicating that UICP may produce a strong seal for subsurface application.

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