– BIOMINERALIZATION SEALING OF LEAKY WELLS –
USING A COMBINATION OF EXPERIMENTS AND MODELING TO DEVELOP A NOVEL TECHNOLOGY FROM THE LABORATORY TO THE COMMERCIAL SCALE

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Within approximately 4 years, a team at Montana State University, in collaboration with Schlumberger, Loudon Technical Services, Montana Emergent Technologies, the University of Stuttgart and others, completed five successful field-scale demonstrations of the ureolysis-induced calcium carbonate precipitation (UICP) technology to restore wellbore integrity. The field work along with the accompanying laboratory scale work and modeling allowed us to validate that engineered calcium carbonate precipitation can be used to seal fractures in the vicinity of leaky wells and restore well integrity. UICP uses either the enzymatic or thermally induced hydrolysis of urea to increase the pH and carbonate alkalinity of aqueous solutions, thus promoting the precipitation of carbonate minerals (see equation in top image of Fig. 1). The resulting precipitates can accumulate in even very small aperture leakage pathways and form seals in situations in which traditional ‘cement squeeze jobs’ have failed to form a reliable seal (see bottom image of Fig. 1). Hence, this technology can provide an alternative to cement-based sealing technologies. The first field-scale demonstration occurred in April 2014, and at the conclusion of 2022 a newly founded company, BioSqueeze®, had successfully sealed over 100 wells for 19 different well operators in seven states in the USA. BioSqueeze® has since expanded operations into Canada.

This presentation will provide a summary of Montana State University’s research and development activities leading to successful commercial applications of this technology by providing an overview of our laboratory, field and mathematical modeling efforts, which were collaboratively conducted with the University of Stuttgart and others. Accompanying work occurred from the single-cell scale to meso-scale reactors, packed sand columns and core samples of up to 70 cm diameter operated at ambient and elevated pressures. Darcy-, pore network-, and pore-scale re-active transport models have been developed and have guided the experimental and field-scale efforts.

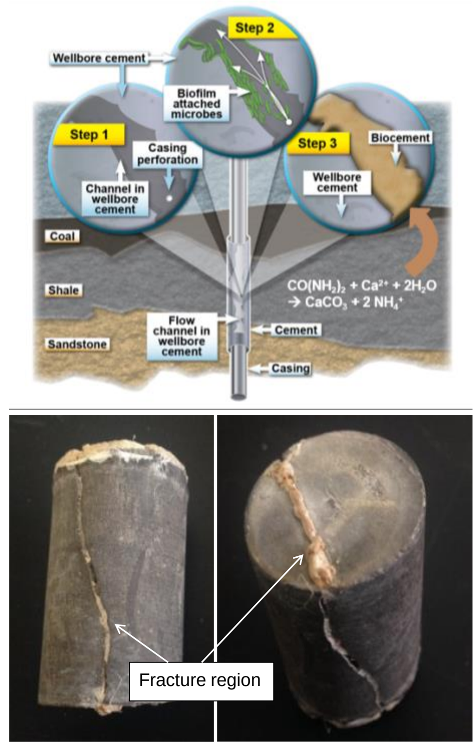

Figure 1: (Top) Conceptual overview of bio-mineralization (UICP) sealing application developed to commercialization (BioSqueeze®). (Bottom): Fractured shale core sealed using the UICP-based biomineralization sealing technology.

We have now developed biofilm and mineral precipitation strategies that can be engineered to manipulate the permeability and mechanical stability of porous and fractured media. We are in the process of engineering biofilm-induced mineral precipitation for the development of beneficial processes including bioremediation, soil stabilization, development of novel building materials, enhanced oil recovery, abatement of saltwater intrusion, enhanced geothermal energy production, and maintenance of well integrity.

Figure 2: (Left) Operations during biomineralization sealing of a well at the Gorgas Powerplant (AL). (Right) Field crew after successful well sealing.

Select Publications:

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