

## Reducing Time of Remediation in Clay and Fractured Rock Sites

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**Background/Objectives:** This presentation focuses on the physics and function of injection/fracturing technologies for remediation with reagent and proppant injection applications in low permeability applications such as clay and fractured bedrock systems including source area and permeable reactive barrier/zone (PRBZ) designs. We will explain the difference between permeation and fracture injection though we may not be able to explain why confusion exists in the industry. Remediation in clay dominant and fractured bedrock environments is among the most challenging remediation site conditions recognized globally, commonly resulting in failed injections, excessive surfacing of injectate, minimal distribution, significant rebound post remediation, unidentified pockets of residual NAPL mass, and years to decades longer remediation timeframes.

**Approach/Activities:** Results and interpretations will be presented for multiple in-situ remediation projects performed across the U.S. An analysis of propagation mechanics for hydraulics is presented to highlight the benefits of the selected approach, (2) the use of proppants is presented to highlight the benefits of reusable proppant fractures, and (3) fracture verification via tilt metering is presented to demonstrate successful radius of distribution results at the beginning of field injection program and for quality assurance (i.e. eye's wide open).

The following site conditions are factored into fracking design.

- Hydrogeology; hydraulic conductivity, permeability, geology, geochemistry and secondary formation features (sand lenses, natural fractures) to ensure appropriate amendment emplacement and reach.
- Proppant physical properties (injection or PRBZ design) and desire for reuse as injection wells.
- Reagent properties to evaluate clay-rock-chemistry (reagent resiliency) interactions and time of remediation short vs long-term treatment objectives.
- Geometry and radius of frack lenses by tiltmeter mapping.

**Lessons Learned:** Fracking with the full understanding of the site geology/hydrogeology and use of 3D tilt metering technology has allowed the authors to overcome diffusion limitations existent at low permeability sites with clay dominant lithology or fractured rock. Through fracking eyes-wide-open, we have been able to transect unidentified preferential pathways and connected pockets of residual mass for more rapid remediation results, reducing the decades long time scale of remediation to less than a few years.