Importance of Fracture Fluid Formulation on Gas/Oil Shale Permeability

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Motivation:

- Poor recovery (Oil < 10%, Gas < 25%
- Fracture fluids can increase and decrease shale porosity
- Mineral scale is produced under a wide range of conditions
- Mineral scale can form over a large spatial scale (m's to nm's)

Questions:

— How does shale mineralogy affect barite precipitation?

— How does mineralogy change when reacted with acidic fracture fluid?

— What changes occur to permeability for shales of different mineralogy?

Experimental Approach:

- Two types of shale cores: Eagle Ford (carbonate-rich), Marcellus (carbonate-poor, with and without microcracks)
- Acidic fracture fluid (pH 2, NETL's Well E recipe)
- Added Ba^2 and SO_4^{2-} to promote barite (S.I. 1.3)
- 3-week (CT-imaging) and 6-day (permeability) reaction (80° C at 77 bar)

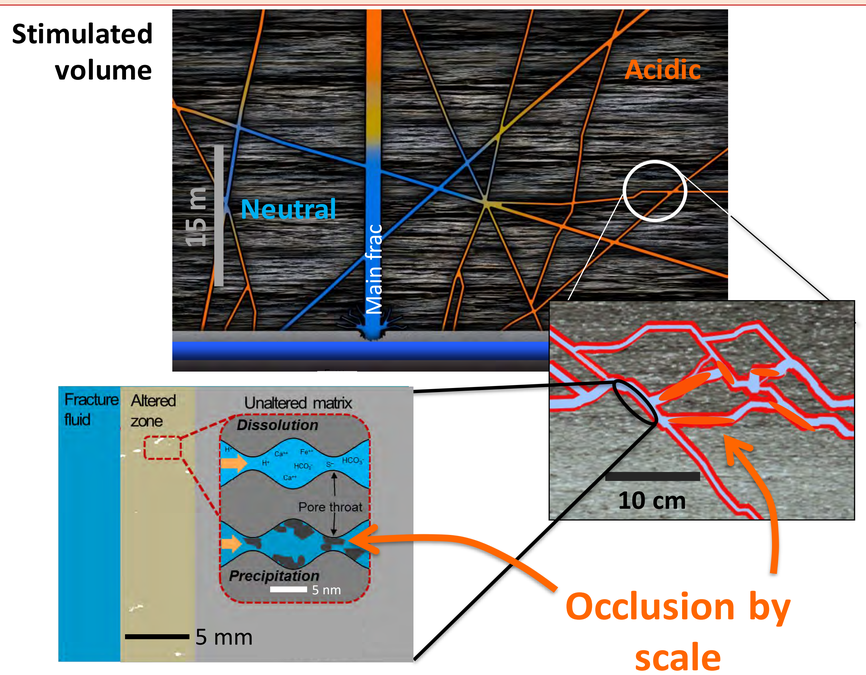
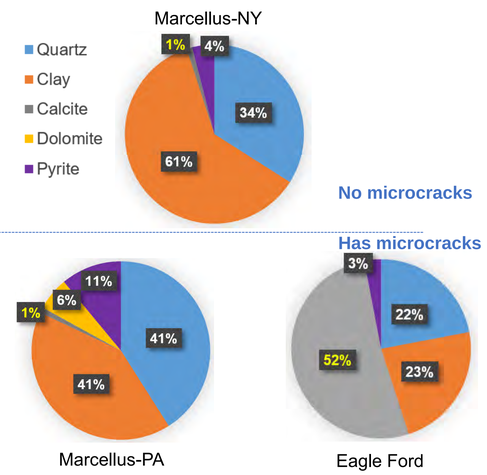


Figure 1: Schematic of mineral scale precipitation on various spatial scales



Synthetic fracture fluid (FF)

Ingredient	Mass	Purpose
Pure Water (contains dissolved O_2)	99.8%	Base fluid
Hydrochloric Acid	0.12%	Acid
Organics	<0.1%	Gellant, friction reducer, scale inhibitor, corrosion inhibitor, etc.

$SI(barite) = \log_{10}(Q/K) = 1.3$

Condition 1: FF

Condition 2: FF + 2 mM $BaCl_2$ + 0.06 mM Na_2SO_4

Figure 2: Experimental conditions

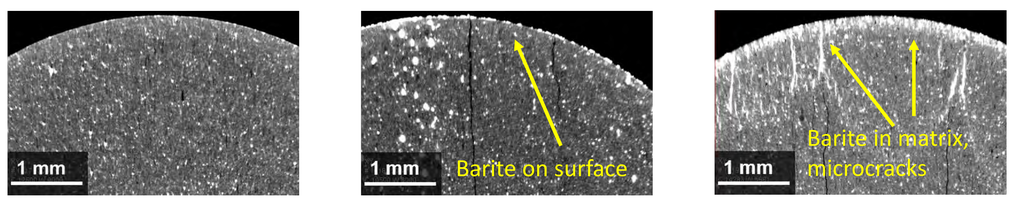
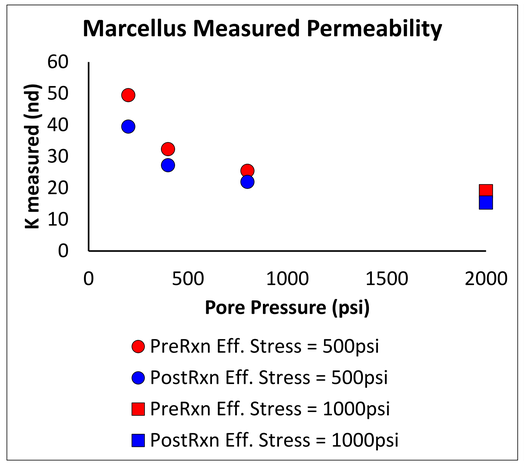


Figure 3: CT images of reacted shales (Condition 2). Marcellus-NY had no visible precipitation.



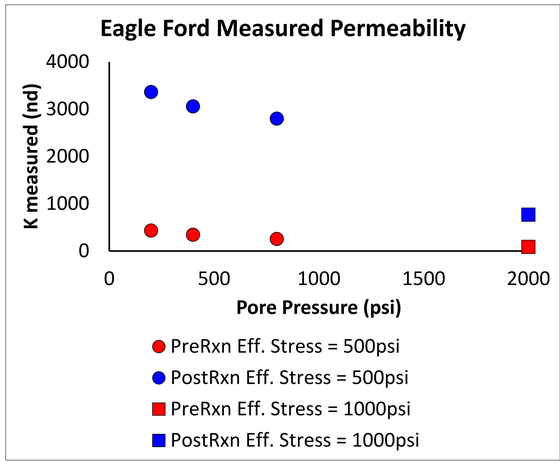


Figure 4: Measured permeability for Marcellus and Eagle Ford Shale (Condition 2)

Major Findings:

- Shales with more pH buffering capacity (more carbonate) have more barite precipitation
- Microcracks are very important because it allows more fluid penetration into shale core
- Acidic fluids drastically increases permeability in carbonate-rich Eagle Ford (1-order of magnitude increase)
- Mineral scale causes a drop in permeability (~7%) for carbonate-poor Marcellus samples
- Though more barite precipitates in Eagle Ford, the amount of secondary porosity formed dominates overall permeability

Outstanding Questions:

- What is the permeability change in the altered zone?
- Overall, where is precipitation most detrimental to production (matrix, fracture surface, or microcracks)?
- Is it possible to tailor the altered zone for maximum permeability through chemistry?
- Do other mineral scaling problems (gypsum, halite, Fe(III)-(hydr)oxides) behave the same as barite?

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