CHEMICAL REACTIVITY OF CANEY SHALE TO KCL-BRINES AT ELEVATED TEMPERATURE AND PRESSURE

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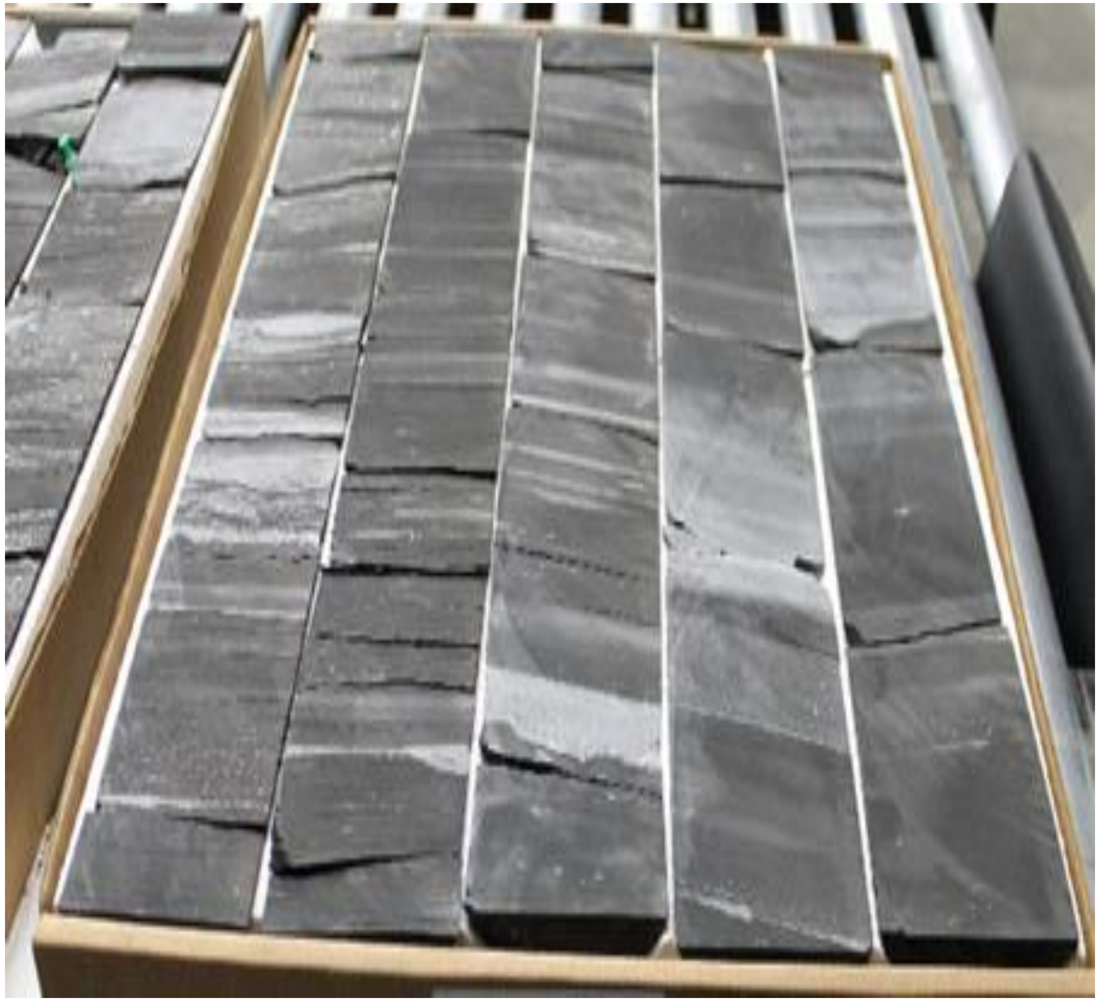
PRESENTATION OUTLINE

- ❑ Introduction
- ❑ Objectives
- ❑ Materials and Methodology
- ❑ Results
- ❑ Conclusions and Recommendations



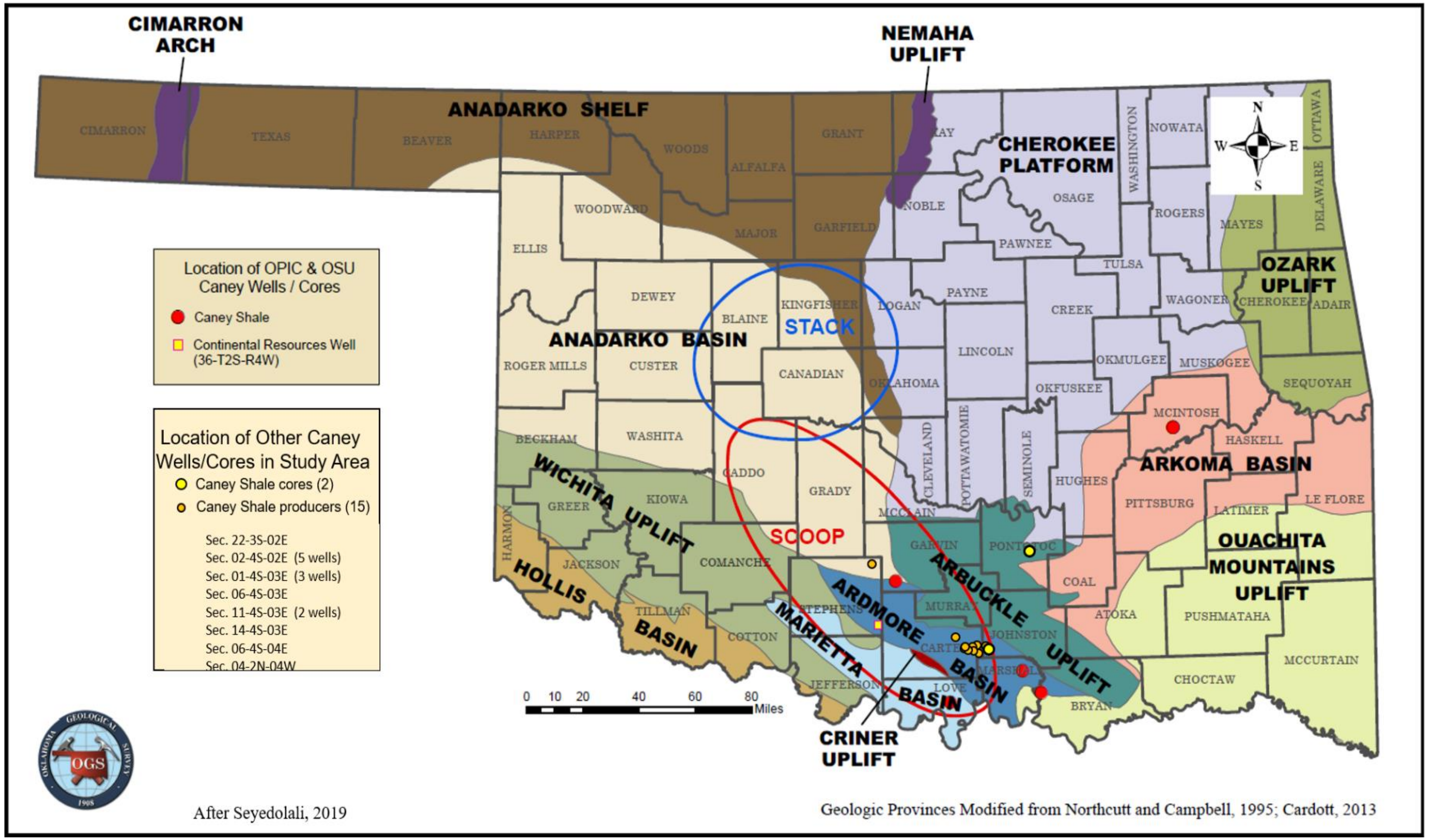
Retrieved Core from Caney Shale on Display

SUMMARY

- Geochemical reactions between rocks and engineered fluids impact petrophysical properties of a formation
- The impacts of these reactions are particularly prominent in micro-fractures and nano-fractures (scale) as opposed to geomechanical forces which act more on macro-fractures more
- Micro-fractures and nano-fractures form extensive networks that reach deep into the reservoir thus very important
- They serve as conduits for hydrocarbon transport to the main fractures and then to the well
- Therefore, any adverse rock-fluid interactions in these zones can greatly reduce permeability thus, productivity from a reservoir
- This research focuses on rock-fluid interactions and their adverse outcomes as well as geomechanical stress impacts on fracture face
- Our work focuses on Caney Shale play South Central Oklahoma Oil Province

INTRODUCTION

- The Caney shale is a newly discovered unconventional reservoir in South Central Oklahoma
- Though known to contain substantial amounts of hydrocarbon, it was designated a seal and/or source rock due to its high clay content
- Advancements in hydraulic fracturing technologies has however unveiled the potential of the Caney Shale
- Recent drilling and exploitation has revealed adverse rock-fluid interactions in the formation

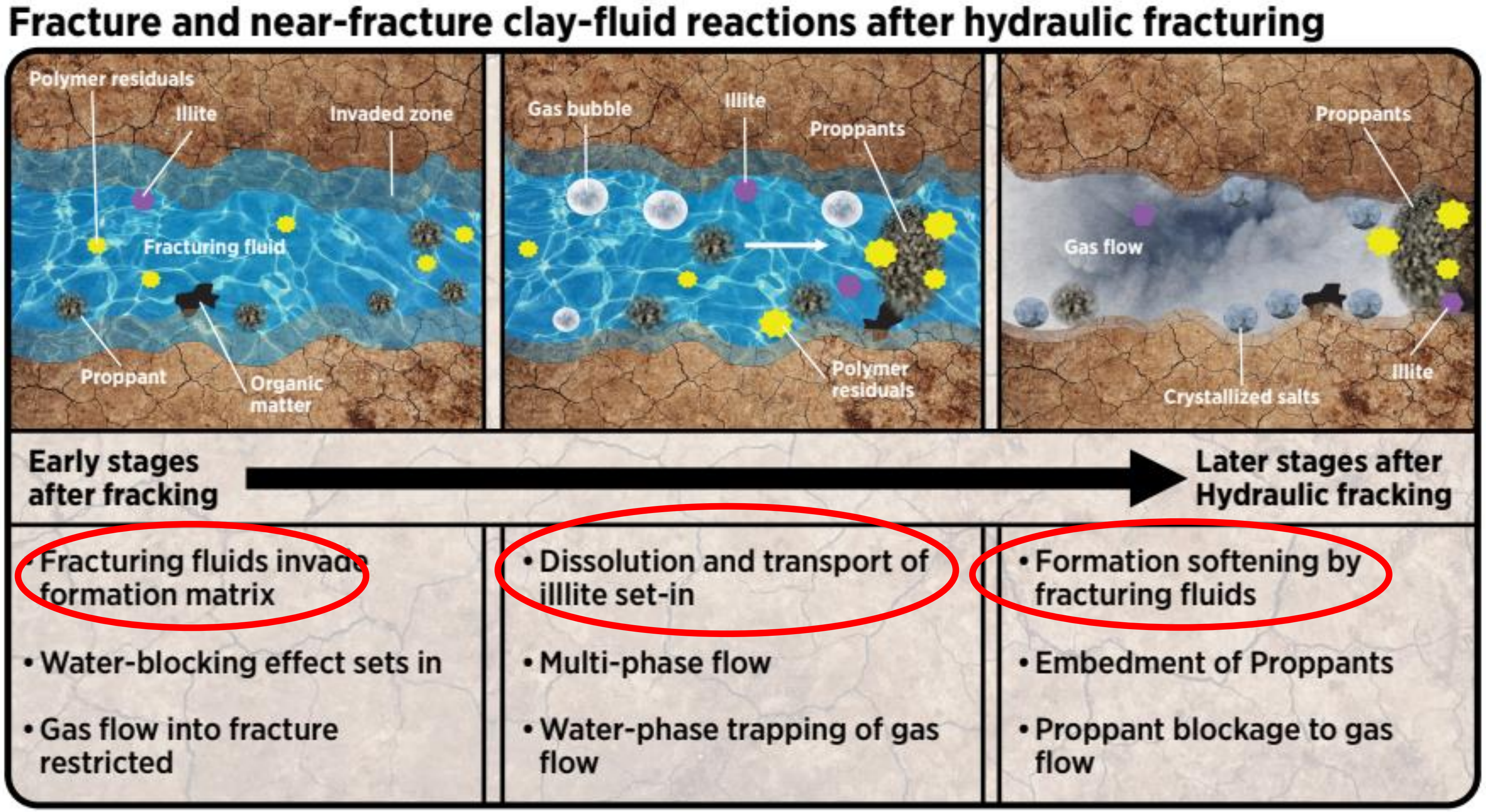


- Geochemical characterization is essential to understanding these interactions and to improving recovery efficiency

OBJECTIVES

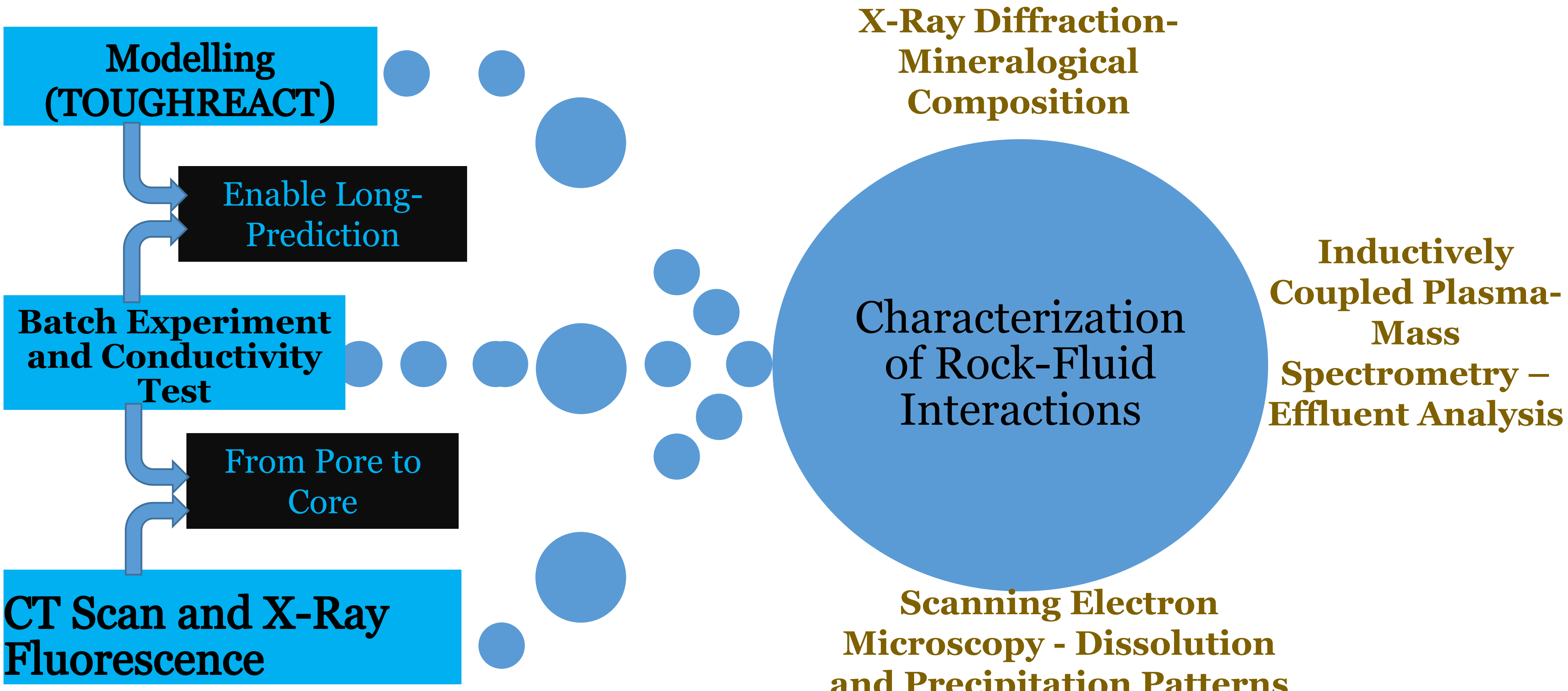
Investigate rock responses to HFFs. Key concerns are:

- Migration of fines (Caney shale has high illite composition)
- Swelling clays and detachment of clay layers
- Dissolution and precipitation of minerals
- Impact of these in occluding fractures and cutting of the connection between well and reservoir



MATERIALS AND METHODLOGY

Three-Pronged Approach: Experiment, Simulation and Logging



MATERIALS AND METHODLOGY

Batch Experiment

- Designed to mimic shut-in period
- Undertaken at Temperature of 90^{o}C and atmospheric pressure
- Initial Liquid to powdered sample ratio of 20:1 (140mL:0.7g)
- Sampling done on days: 1, 4, 7, 14, 21 and 28 (10mL sample)

Conductivity Test

- Proppant (40/70) sandwiched between half piece of core sample
- Changing Stresses applied, 4000-12000 and back to 4000
- Width, Permeability and Conductivity measured

Materials Used:

Three fluid samples of varying compositions:

- 2% Potassium Chloride Solution (pH~4)
- 0.5% Choline Chloride Solution (pH~4)
- Deionized Water (Base, pH~7)

Three rock samples selected at different depths:

- High Quartz (HQ)

  [74.4% Quartz, 9.6% Carbonate and 16% Clay]
- Moderate Quartz, Carbonate and Clay (MQ)

  [63.1% Quartz, 17.1% Carbonate and 19.8% Clay]
- High Clay (HC)

  [41.5% Quartz, 14.1% Carbonate and 44.4% Clay]

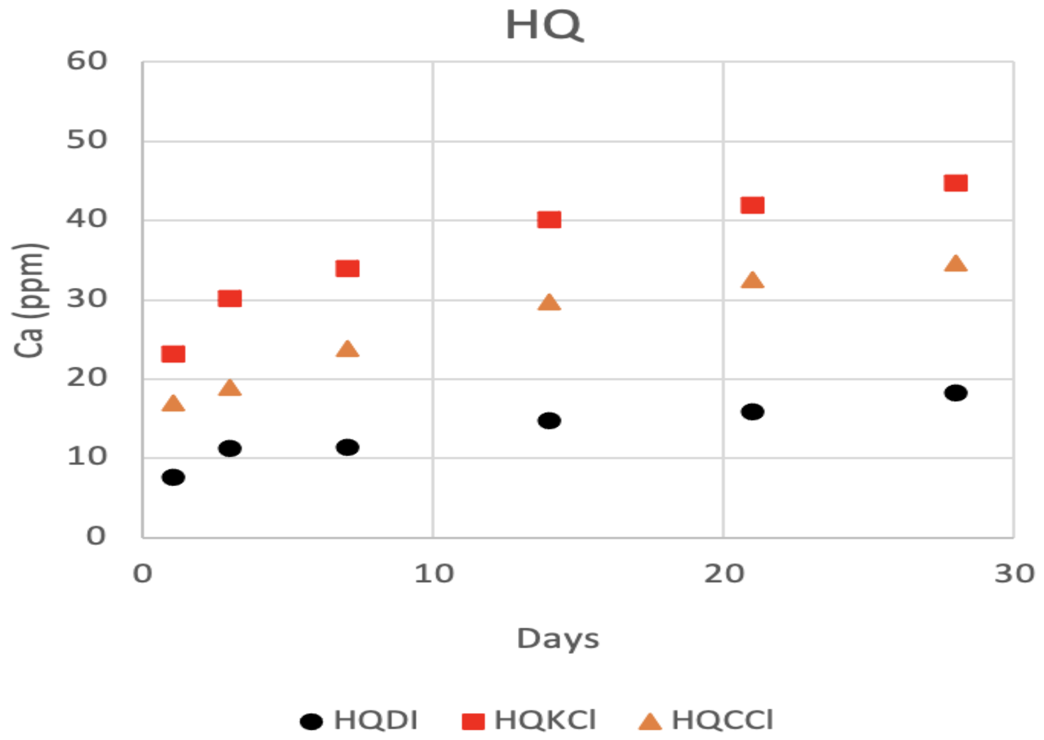
RESULTS

Identifying the key driving force that can cause varying outcomes for rock-fluid interactions

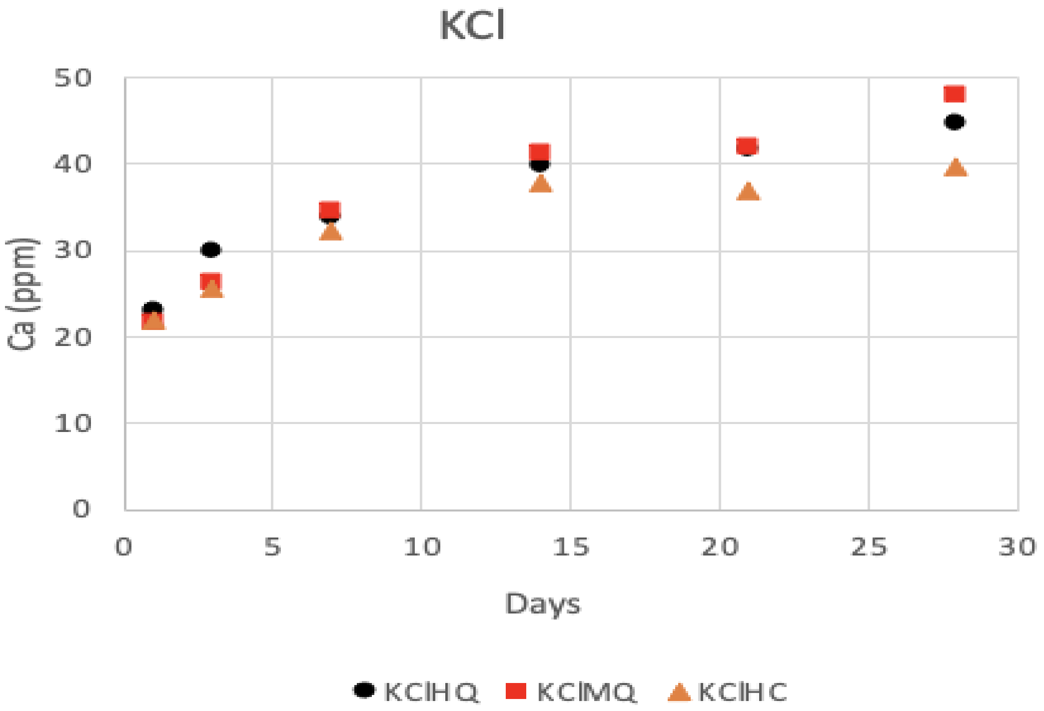
Question: Is it the fluid or it is the rock?

Answer: Obviously the fluid

Impact of Fluid Composition on elemental concentration in effluent



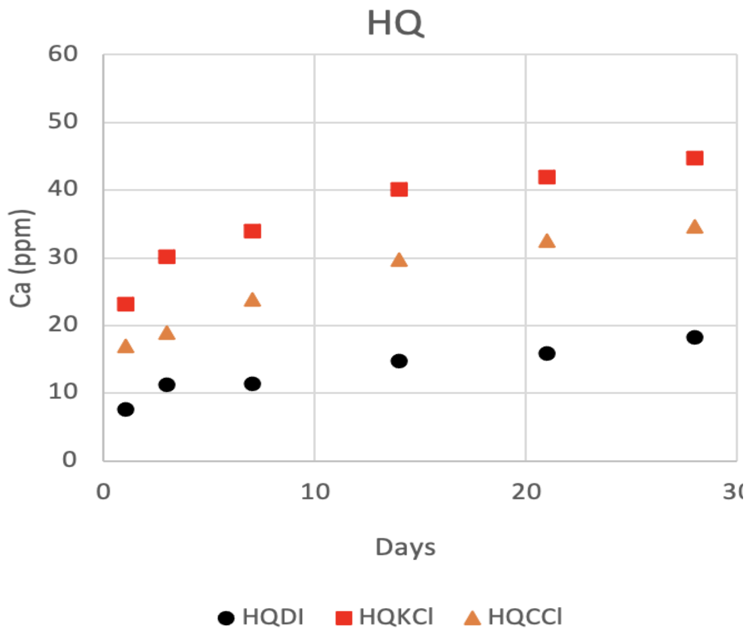
Impact of Rock Composition on Elemental Concentration in effluent

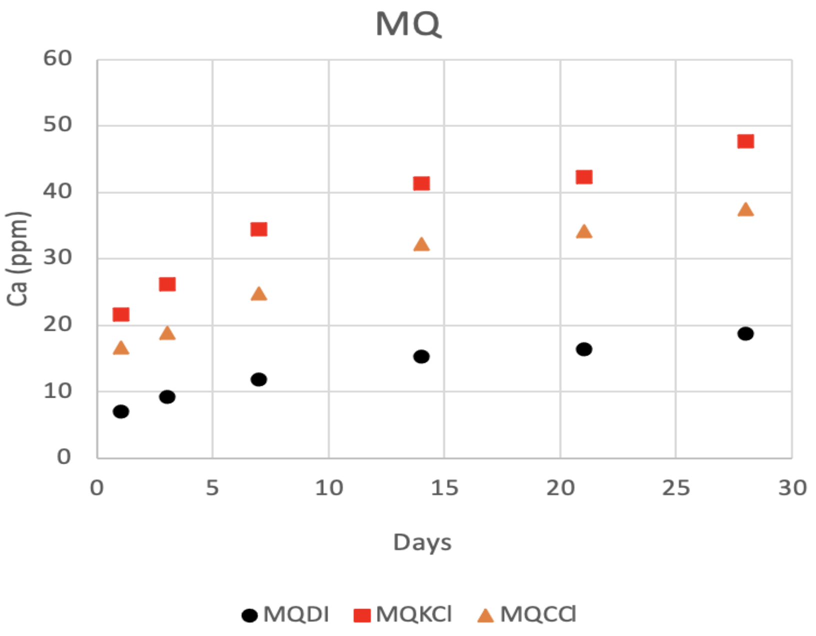


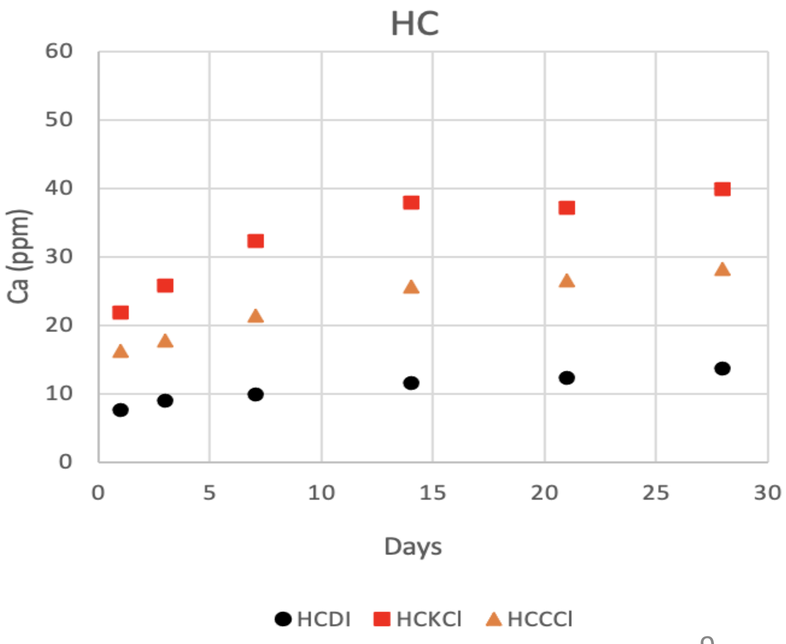
RESULTS

Calcium ion:

- Ca ion concentration distinguishable for each fluid type
- Ca ions in solution believed to be from Calcite and Dolomite Dissolution
- Potassium Chloride>Choline Chloride>Deionized water (In terms of ion concentration in solution)
- HQ and MQ samples have higher concentrations than HC sample



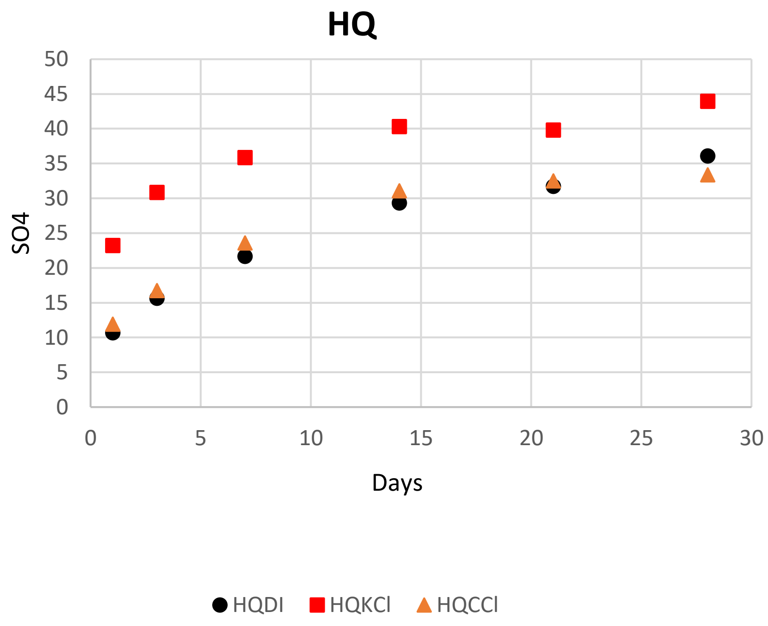


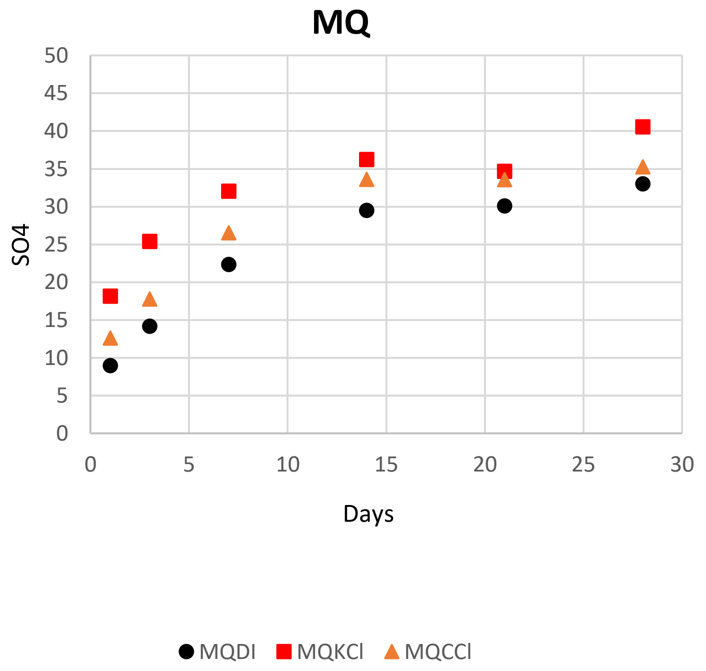


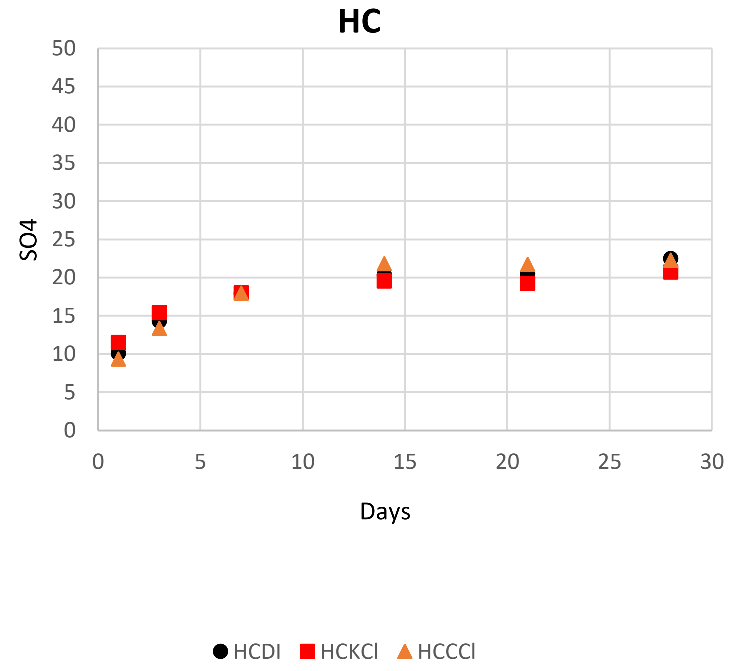
RESULTS

Sulphate ion:

- SO4 ion concentration distinguishable for each fluid type
- SO4 ions in solution believed to be mainly contributed from the Dissolution of Pyrite
- Potassium Chloride>Choline Chloride>Deionized water (In terms of ion concentration in solution)
- HQ and MQ samples have higher concentrations than HC sample



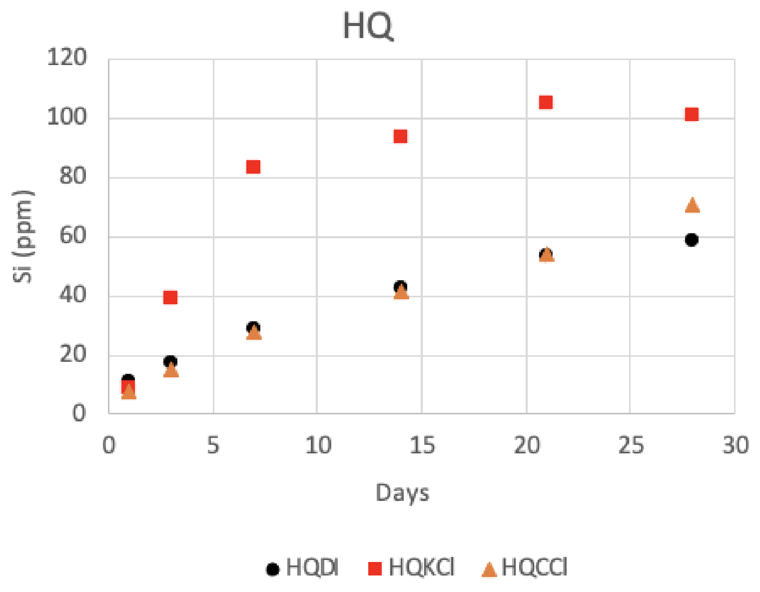


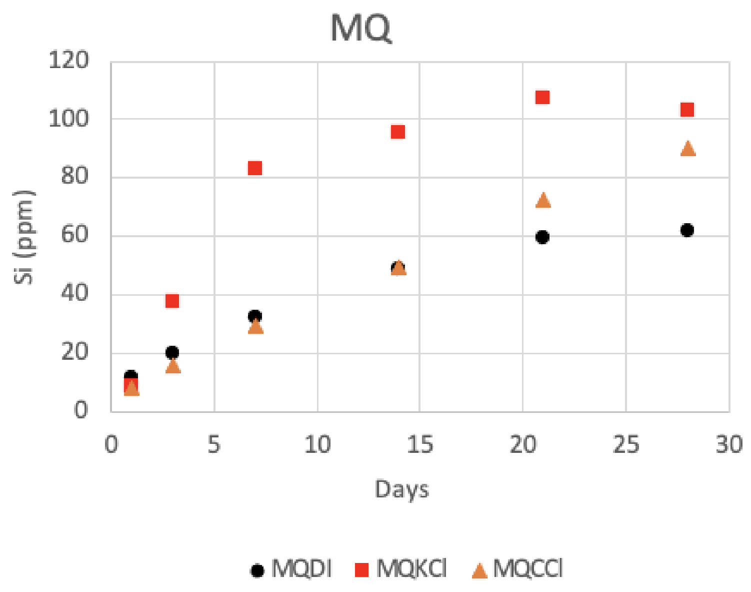


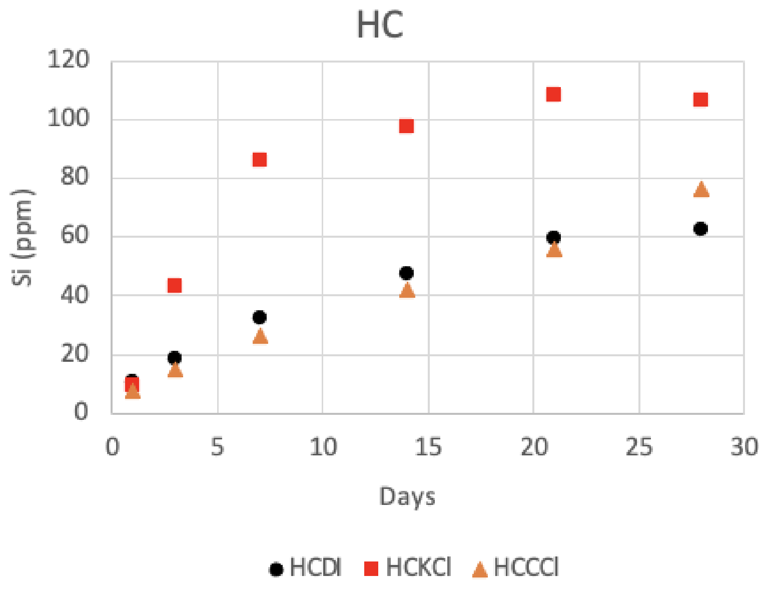
RESULTS

Silicon ion:

- Si ion concentration for various fluids clearly distinguishable
- Si ions in solution believed to be from quartz and clay minerals
- Potassium Chloride>Choline Chloride>Deionized Water (In terms of ion concentration in solution)
- Si ions most likely from the clay and feldspathic component of the rock





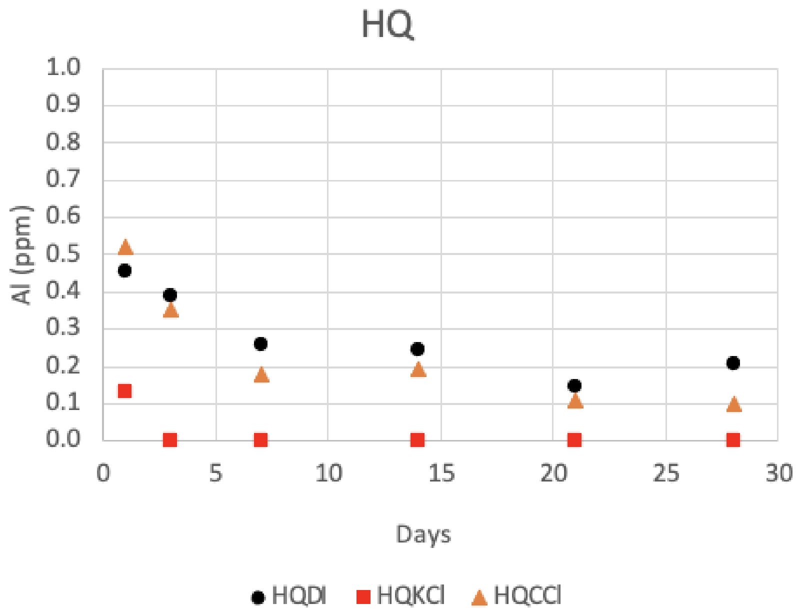


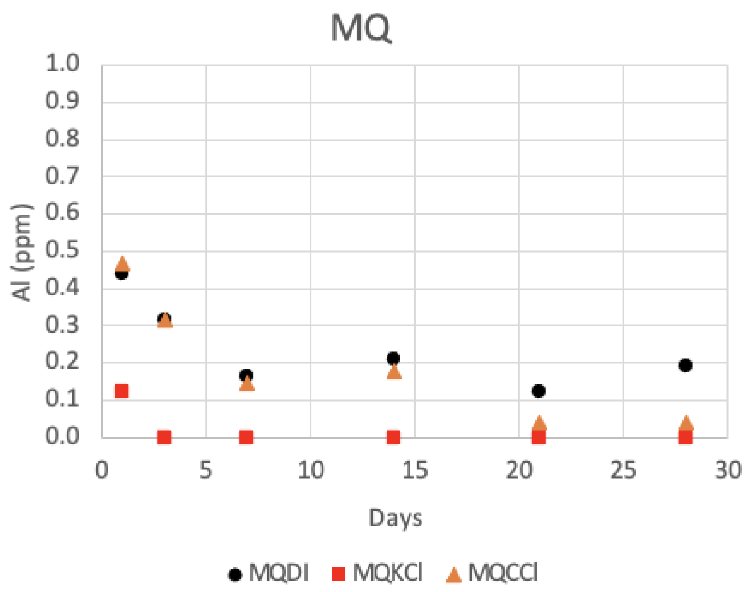
RESULTS

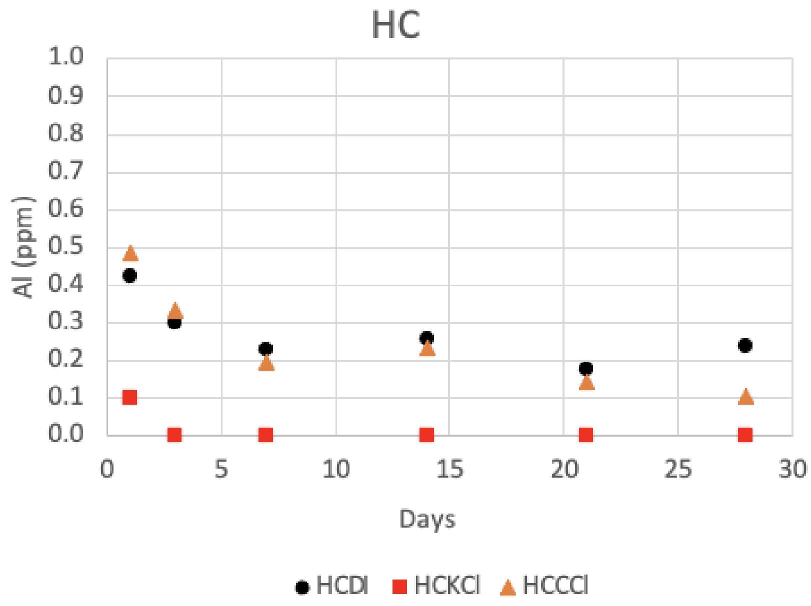
Al and Mg ions show sharp decline in concentrations: Two theories exists:

- Precipitation
- Substitution or Adsorption

- Aluminum elements in solution are from dissolution and cation exchange in clay minerals
- Magnesium elemental concentration is mainly from dissolution of dolomite, but clay dissolution and cation exchange in clays may also contribute

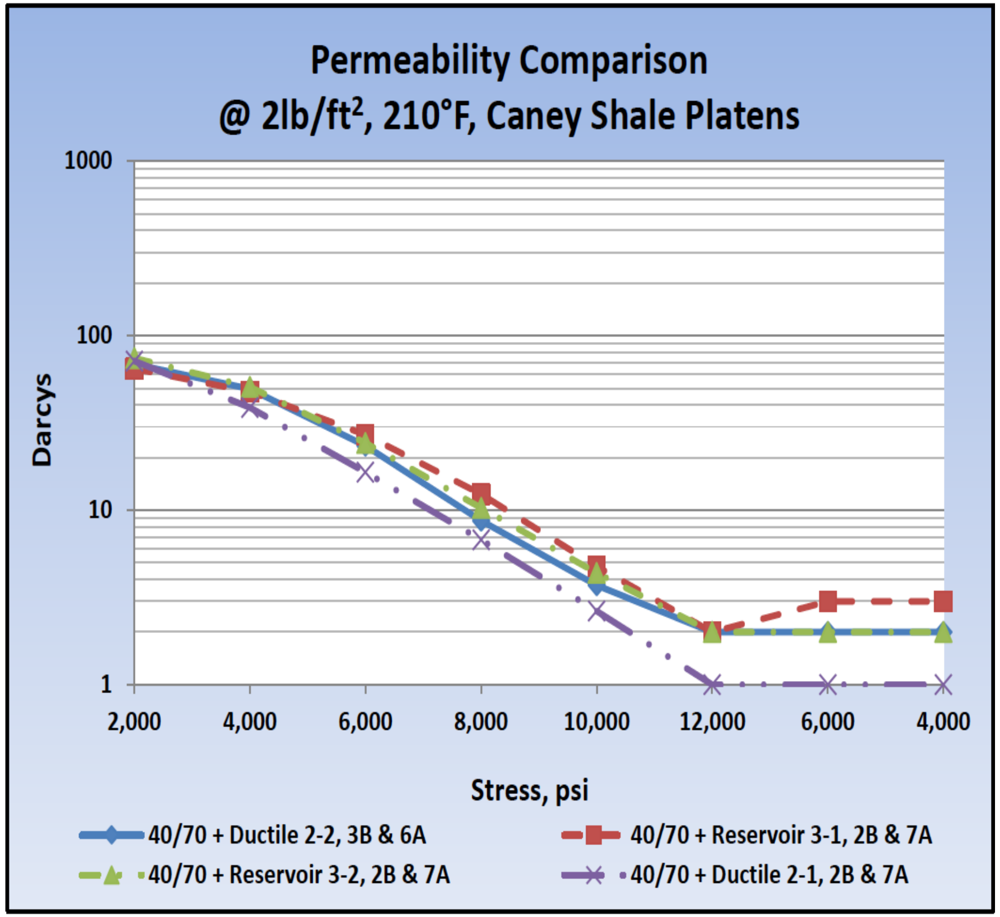


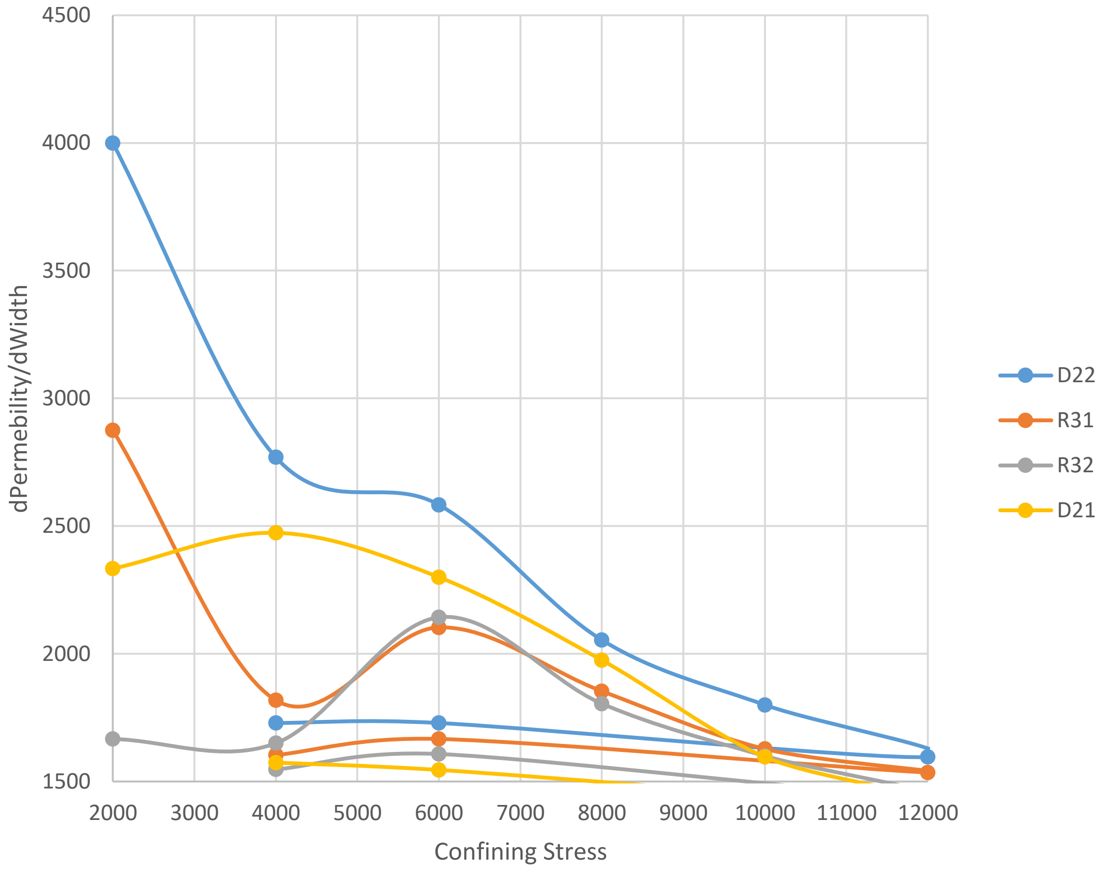




RESULTS

Stress Impact on Width, Permeability and Conductivity





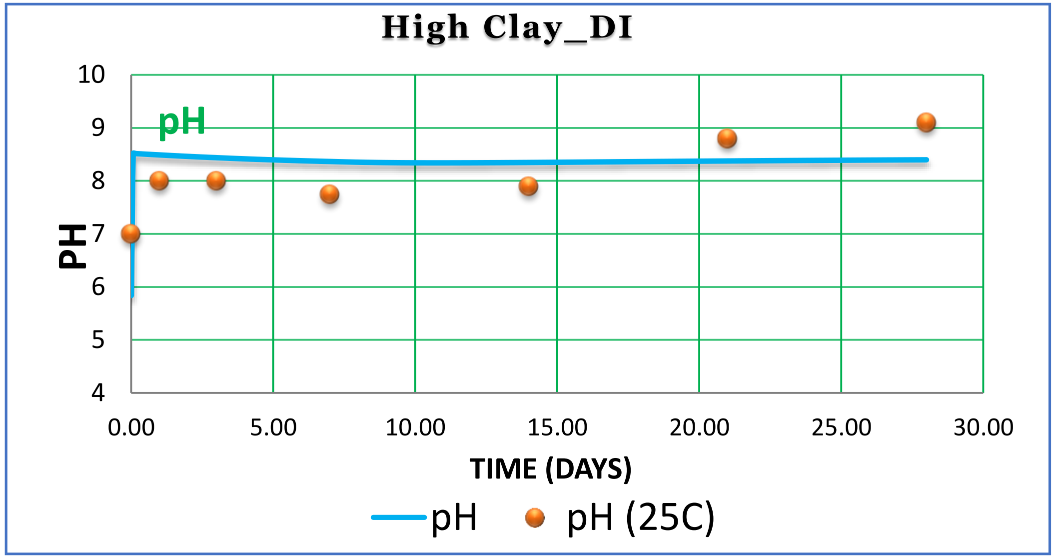
RESULTS

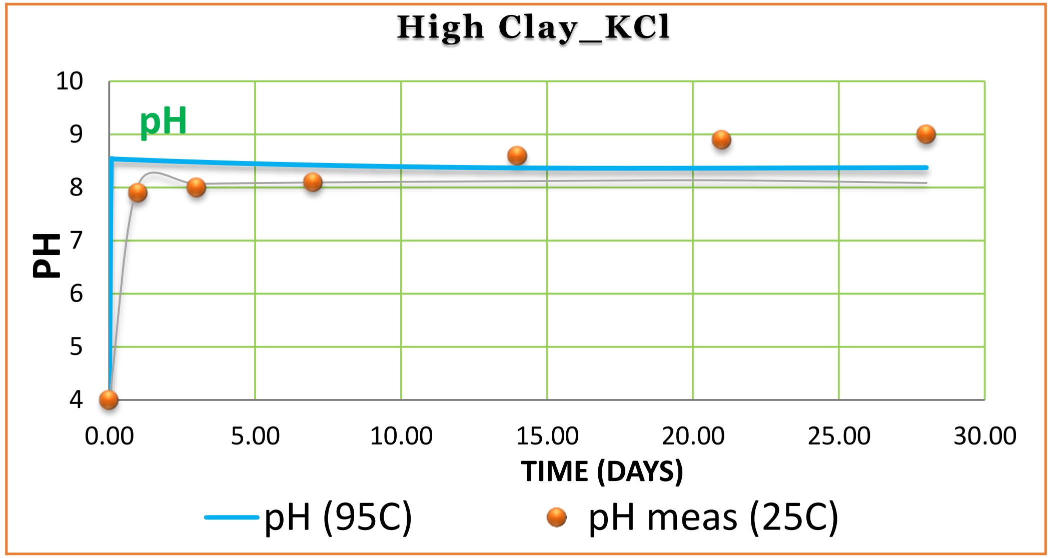
Stress Effect on Conductivity

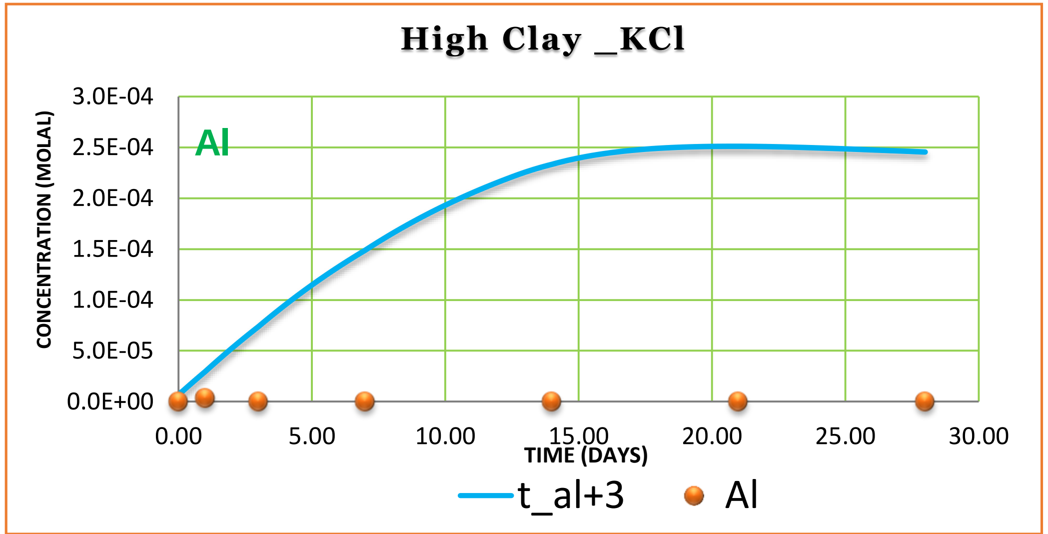
40/70 + Ductile 2-2, 3B & 6A								
Stress (psi)	2000	4000	6000	8000	10000	12000	6000	4000
Conductivity (md-ft)	1376	952	428	150	62	25	31	32
40/70 + Reservoir 3-1, 2B & 7A								
Stress (psi)	2000	4000	6000	8000	10000	12000	6000	4000
Conductivity (md-ft)	1263	878	481	208	76	37	40	41
40/70 + Reservoir 3-2, 2B & 7A								
Stress (psi)	2000	4000	6000	8000	10000	12000	6000	4000
Conductivity (md-ft)	1466	948	435	173	70	32	36	39
40/70 + Ductile 2-1, 2B & 7A								
Stress (psi)	2000	4000	6000	8000	10000	12000	6000	4000
Conductivity (md-ft)	1451	744	301	118	43	20	22	23

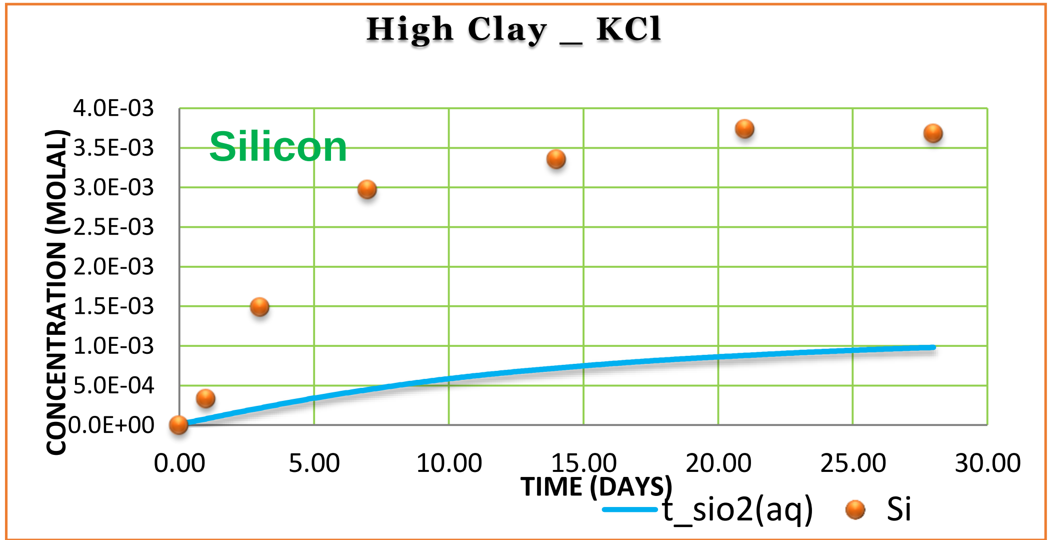
RESULTS

Except pH values, modelled values and experimental values showed significant disparities

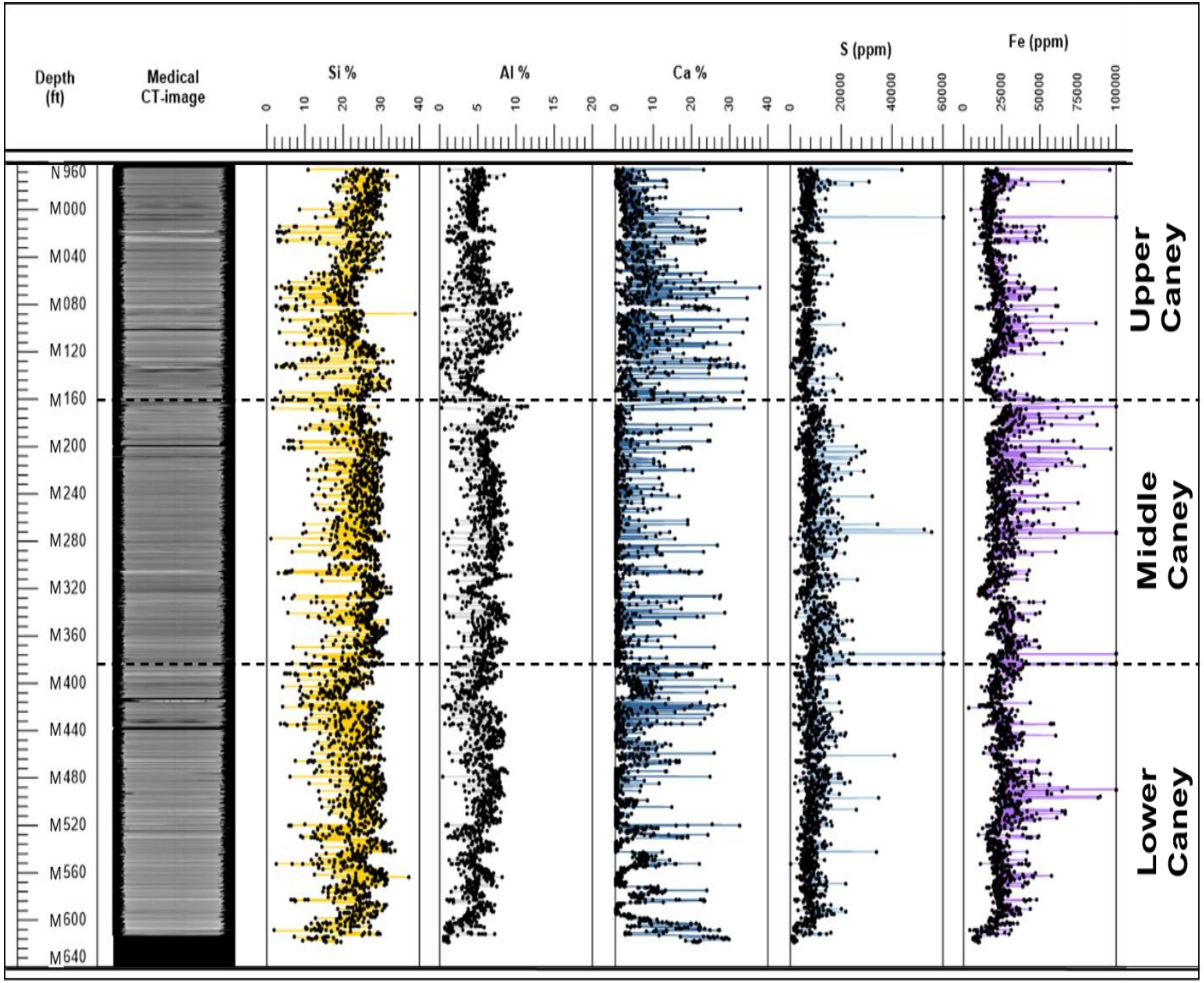








RESULTS



Three informal Divisions based on XRF results:

- Upper Caney shows decreased Si concentration through heavily bioturbated intervals and Al and Fe rich intervals (Clay and Carbonate Rich Zone)

- For the middle Caney, Al and Si concentrations remain consistent whilst Ca is low (Quartz-rich shale zone)

- In the lower Caney, sharp increase in Ca is observed whilst Al and Si constant (Carbonate zone followed by High Quartz Shale)

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- Rock-fluid interaction during hydraulic fracturing is largely the function of fluid composition
- Carbonates and Clays are more susceptible to geochemical interactions whilst Quartz is relatively stable
- Increasing clay composition in samples impact dissolution of quartz and carbonate minerals thus less fracture opening
- Potassium Chloride and Choline Chloride stabilized clay minerals
- Mechanism of stabilization is continuous exchange of ions between clays and fluid
- This will help prevent swelling and disintegration of clays thus micro and nano-fractures remain open
- Sustainability of stabilization looks unlikely??
- Substitution of ions may be responsible for low Al and Mg ion concentration since these ions are both exchangeable cations
- Stress has an impact on permeability and conductivity, though limited
- Conductivity of ductile samples is higher per unit change in fracture width

Recommendations:

- Working on improving geochemical and physical characterization for modelling in our next work
- Further work to be done to clearly understand Al and Mg ion concentration trends
- Longer experiments to determine the limits of effectiveness of temporary clay stabilizers considering pH values continued increasing for entire batch experiment

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