Theme 1: Fluid Assisted Geomechanics

Specific scientific goals:

- Advance the understanding of time-dependent **chemo-mechanical coupling** in heterogeneous geomaterials by identifying mechanisms and time/length scales for self-reinforcing **sub-critical fracture propagation**

- Develop a **predictive capability** for the emergence of fracture networks **above a threshold** (of length, spacing, transmissivity, etc.) at which significant migration of a buoyant fluid phase becomes possible

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Research Challenges Addressed:

- ***Achieving material rates*** as injection causes fractures to propagate from injection wells, and the ability to predict the threshold at which injection induced fracturing can lead to significant deviations in plume migration is critical for designing an optimal injection strategy
- ***Improving storage efficiency*** as plume migration along undesired pathways can decrease the storage efficiency
- ***Controlling emergent behavior*** if fracture networks extend sufficiently far into caprocks, or if injection induces or triggers seismicity, or damages wellbores over a range of time and spatial scales

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Motivation:

- ***Fluid-assisted fracture geomechanics*** imparts a time-dependency to the frictional, plastic deformation of geomaterials due to:
  - pore fluid diffusion within fractures (and between fractures and porous matrix,
  - chemically-assisted deformation
- ***Hydromechanical and hydromechanical-chemical coupling*** are critically important deformation mechanisms in the subsurface. Operational constraints may make such coupling inevitable - the ability to control or mitigate them will also be valuable

Theme 1: Activities

- ***Experimental fracture dynamics with chemo-mechanical coupling***
  - Experiments to develop constitutive models for crack propagation, frictional slip (including time-dependent effects), and bulk rock strengthening/weakening associated with chemical effects
  - Collaboration with Theme 2 to evaluate mudstone dry-out and clay intercalation with $scCO_2$ as a mechanism for leakage pathway development

- ***Constitutive modeling of fracture tip and asperity evolution***
  - Study pore-scale chemical and mechanical-damage processes at crack tips and asperities via direct embedding of pore-scale multiphysics models within a "far field" continuum scale model.

Theme 1: Activities

- ***Modeling reservoir-scale effects of coupled flow, chemical and mechanical-damage processes***
  - Implement and extend phase field models to multiphase flow, and incorporate additional effects due to chemical reactions and frictional behavior

- ***Assessing engineered nanoparticles as potential control agents***
  - Develop in collaboration with Theme 3, nanoparticles or chemicals that control crack tip generation, shear fracture growth and/or bulk rock weakening

- ***Field-based fracture network assessments***
  - Evaluate spatial and structural characteristics of fracture networks in natural CO_2-rich fluid environments such as at St. Johns Dome, Bravo Dome, Little Grand Wash fault

Theme 1: Researchers and Activities

	THEME 1: FLUID-ASSISTED GEOMECHANICS			
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RESEARCH ACTIVITIES

1) Fracture propagation and rock deformation
2) Multi-scale modeling
3) Phase field modeling
4) Cohesive zone modeling
5) Fracture network analog sites
6) Bulk rock weakening evaluation
7) Influence of chemistry in frictional slip
8) Engineered nanoparticles as control agents

* - Shared with Theme 3, ** - Shared with Theme 2