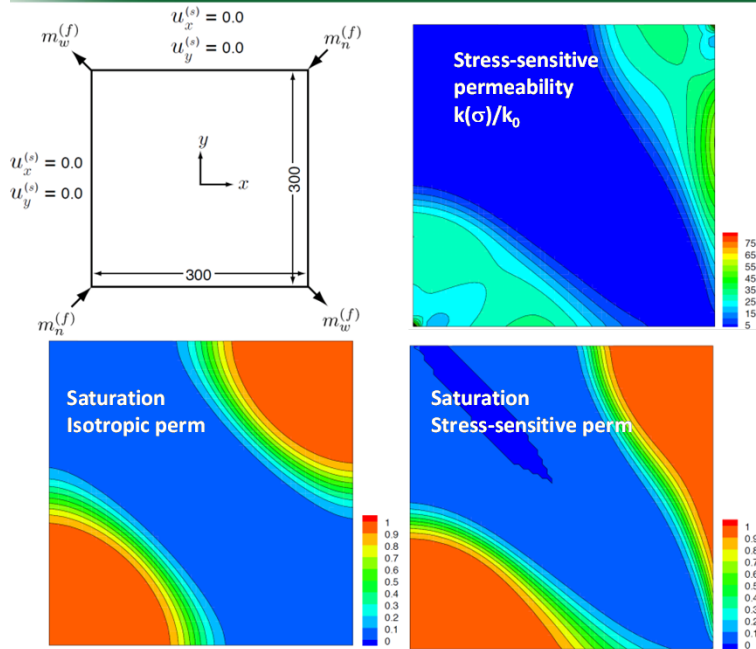


# Models for Nonlinear Subsurface Flow and Geomechanics



**5-spot waterflood into a homogeneous (lower left) and a stress-sensitive, heterogeneous (lower right) reservoir. Injection-pressure-induced stresses fracture the reservoir thereby inducing increased, heterogeneous permeability ( $k/k_0$ ) and increased (decreased) water cut at lower right (upper left) production wells.**

Turner, et al., 2014, Framework for coupling flow and deformation of a porous solid, Int. J. Geomech., DOI: 10.1061(ASCE)GM.1943-5622.0000416.

Work performed at Sandia National Laboratories.

## Scientific Achievement

Developed a generalized mathematical framework based on theory of interacting continua for coupled subsurface flow and geomechanics processes.

## Significance and Impact

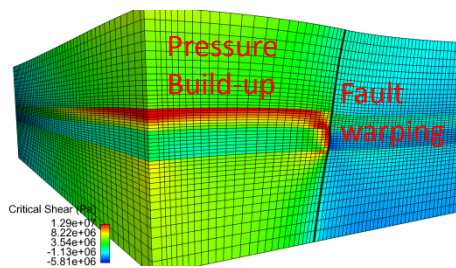
The framework facilitates modeling coupled physics in a conveniently implemented fashion.

## Research Details

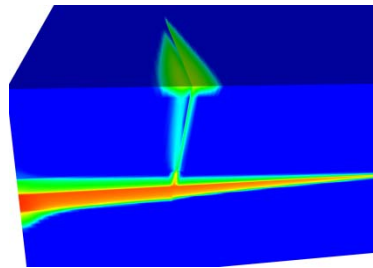
- A generalized mathematical framework for coupled flow and geomechanics was developed.
- The interaction between fluid and solid appears in the form of a drag-like term.
- The framework enables modeling of stress-sensitive reservoirs to study injection pressurization effects on caprock integrity.
- The framework facilitates code development by placing the models into a generic continuum mechanics setting.
- The framework allows extension to model coupled reactive processes.

# Models for Fluid-Induced Geomechanics Processes for Geologic Carbon Storage

## Impact of faults on critical shear failure and leakage

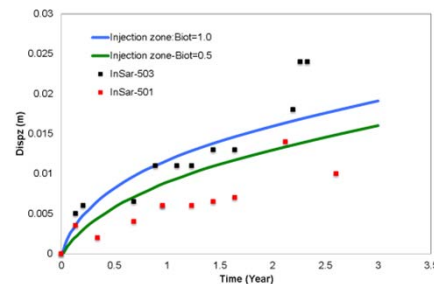
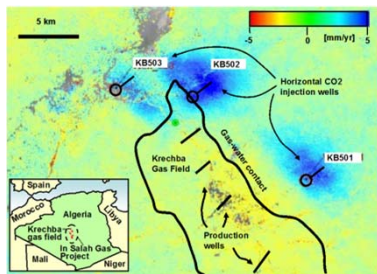


**Low permeability** fault impedes CO<sub>2</sub> injection and builds pressure behind the fault, inducing critical shear failure in both the caprock and fault.



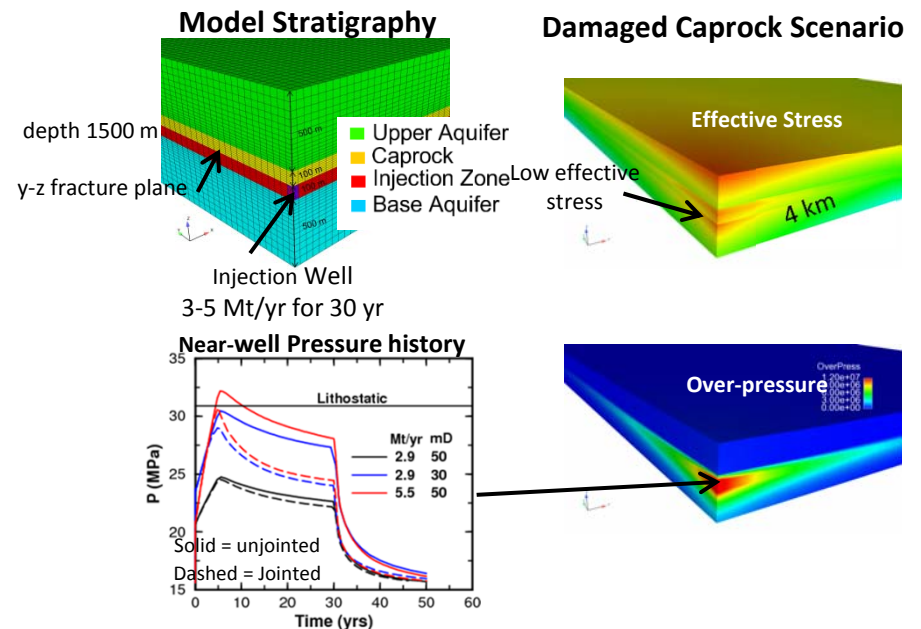
**High permeability** fault creates a pathway for leakage of CO<sub>2</sub> through the caprock.

## In Salah Application



**Impact of geomechanical and hydrological properties on injection-induced uplift at InSalah**

## Jointed Rock Model



**High injection rates and/or low storage aquifer permeability can lead to fracturing of the caprock, inducing leakage.**

Bishop et al., ARMA 12-190 (2012)  
 MJ Martinez et al., Int. J. Greenhouse Gas Control, 17, 148-160 (2013)  
 Turner, et al., (2014) Int. J. Geomech., DOI: 10.1061(ASCE)GM.1943-5622.0000416.  
 Newell, et al., Systematic Investigation of the Influence of Geomechanical and Hydrogeological Properties on Surface Uplift at In Salah, (2015)submitted.