SAND2013-7523P

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Parameter estimation and uncertainty quantification of reservoir and geomechanical modeling of surface uplift at In Salah, Algeria

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Objectives

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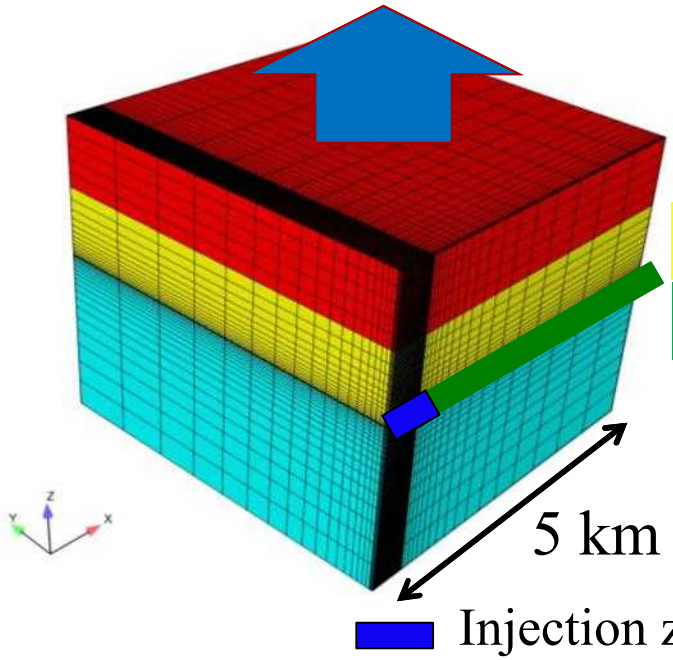
The motivations and objectives for this study are as followings:

- Validation of coupled flow and geomechanics model against observed uplift at In-Salah (led by Pania Newell)
- Testing of conceptual models with different parameterizations
- Inverse modeling for estimating key material parameters (e.g., permeability, anisotropy, Biot coefficient, # of layers within each formation, Kayenta model)
- Uncertainty quantification for several key conceptual models

Objectives

Uplift at the surface



Observed data:

Uplift at the surface (KB501 & KB503 wells)

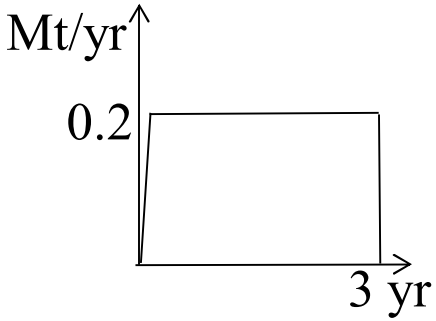
Maximum pore pressure within the injection layer

Overburden (900m)

Caprock (900m)

Injection layer (20m)

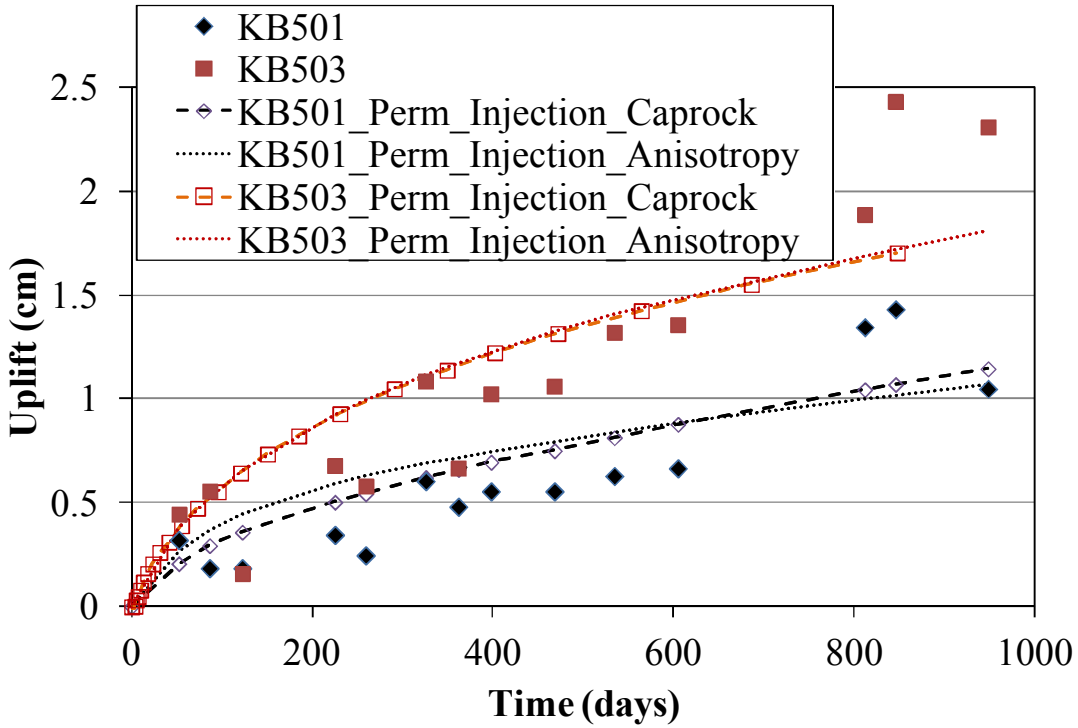
Base aquifer (2180m)



CO2 injection rate

- Key multiphase flow parameters are obtained from literature
- Caprock and overburden layers with multiple sublayers will be tested
- Each (sub) layer will be parameterized with different sets of permeability, anisotropy, and Biot coefficient depending on sensitivity analysis

Calibration results with two parameters using a multi-start gradient method (no Kayenta model)



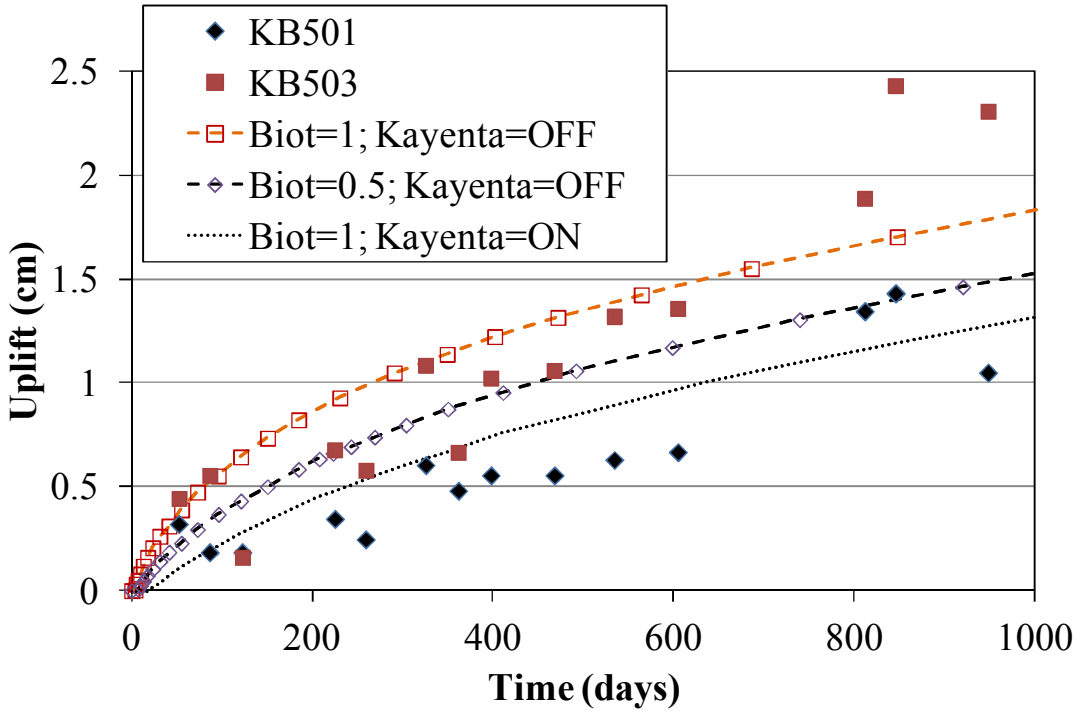
	KB501 data		KB503 data	
	k Inj_Cap	k Inj_Aniso	K Inj_Cap	K Inj_Aniso
kz_cap	2.15E-18	1.00E-19	1.00E-19	1.00E-19
kx_cap	2.15E-18	1.00E-19	1.00E-19	1.00E-19
kz_inj	5.66E-14	1.35E-15	1.32E-14	9.44E-16
kx_inj	5.66E-14	2.26E-14	1.32E-14	1.29E-14

Parameters of interest (values in parenthesis are the reference):

- Intrinsic permeability of caprock (1.0E-19m^2) & injection zone (1.3E-14m^2)
- Anisotropy ratio of caprock (1.0) & injection zone (1.0)
- Biot's coefficient of injection zone (1.0)
- Presence of pre-existing joints (Kayenta model)

- Multiple calibrated models can match the observed data
- Horizontal permeability of the injection zone is sensitive to the observed data

Reference case with Biot coefficient and Kayenta model



- Both lower Biot coefficient (0.5) and inclusion of the pre-existing fractures within the injection zone (Kayenta=ON) affect the degree of uplift considerably
- Parameter estimation with other parameters is required

Work Plan

- Calibrate multiple calibrated models against the observed uplift and pressure data
- Several optimal sets of parameterization (# of sublayers and parameters within each sublayer) will be evaluated
- Computationally efficient parameter estimation and uncertainty quantification is required (e.g., non-gradient based search, polynomial chaos expansion, null-space Monte Carlo with Latin-Hypercube sampling)
- DAKOTA (Design Analysis Kit for Optimization and Terascale Applications) will be used

This material is based upon work supported as part of the Center for Frontiers of Subsurface Energy Security, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Award Number DE-SC0001114.