SITE CHRACTERIZATION FOR GEOMECHANICAL AND FLOW MODELING AT WEST PEARL QUEEN PILOT SITE

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Outline

- INTRODUCTION
- METHODOLOGY
- RESULTS
- DISCUSSION

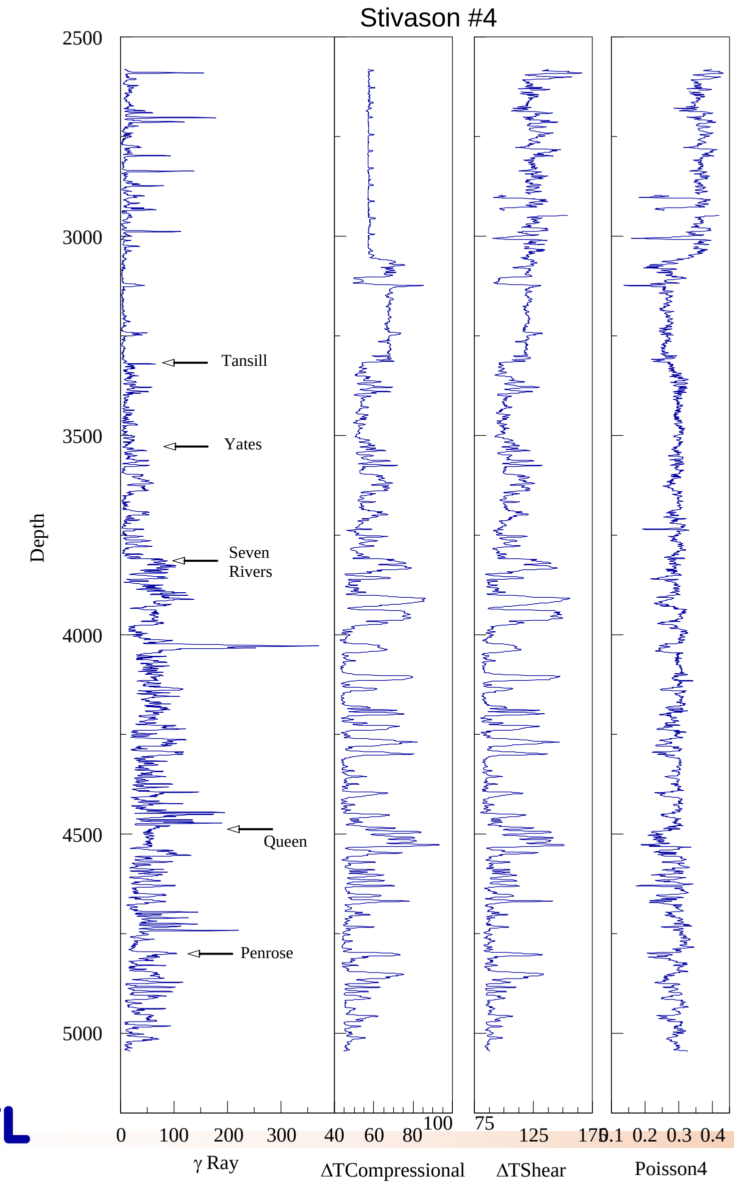
Introduction

- **The West Pearl Queen field is located in SW New Mexico in the Permian basin.**

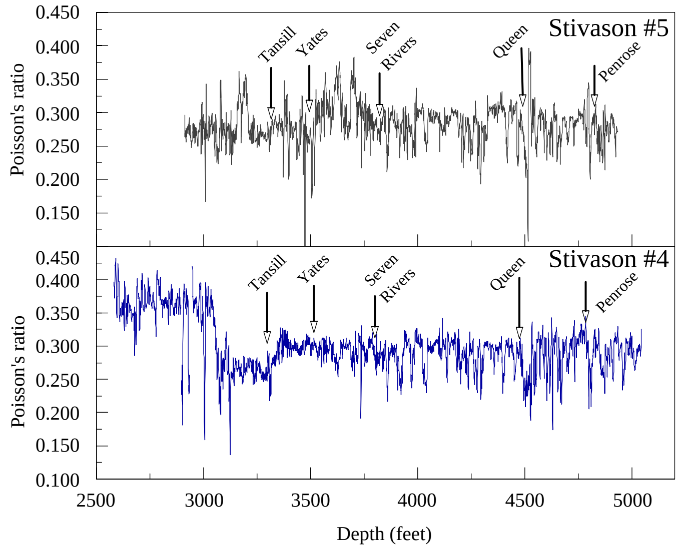
Introduction

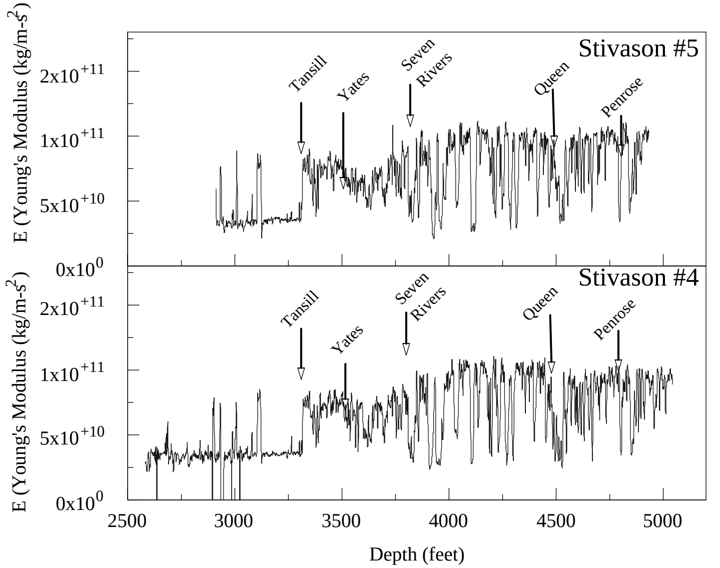
- The location is a depleted oil field.
- The field experiment was started in 2002 and completed in 2003.
- Details of the pilot scale test are given elsewhere (Westrich, 2001; Pawar et al. 2001; Pawar et al., 2003).

Methodology



The γ ray log, Δt compressional wave and shear wave, and poisson's ratios are shown at left for the Stivason #4 injection well.



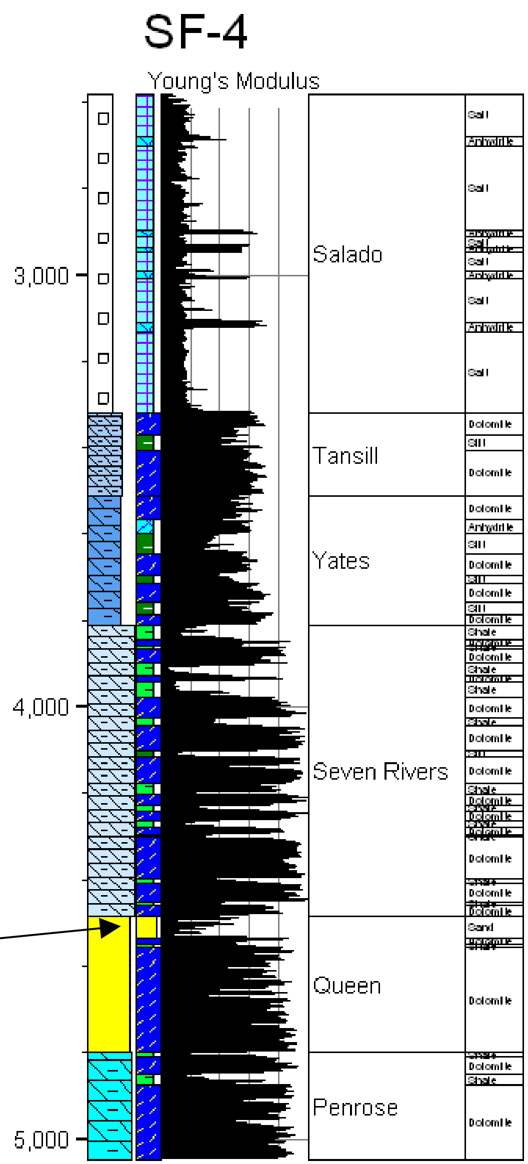


At left is a comparison of estimated Young's modulus and Poisson's ratios for the Stivason #4 and #5 wells.

The following equation was used to estimate Young's modulus from VP, VS, and ρ.

$$E = \rho V_s^2 \left(\frac{3V_p^2 - 2V_s^2}{V_p^2 - \frac{1}{3} V_s^2} \right)$$

$$[E] = \frac{kg}{m - s^2}$$



Shattuck

Variations of Young's Moduli associated with major stratigraphic subdivisions of the area

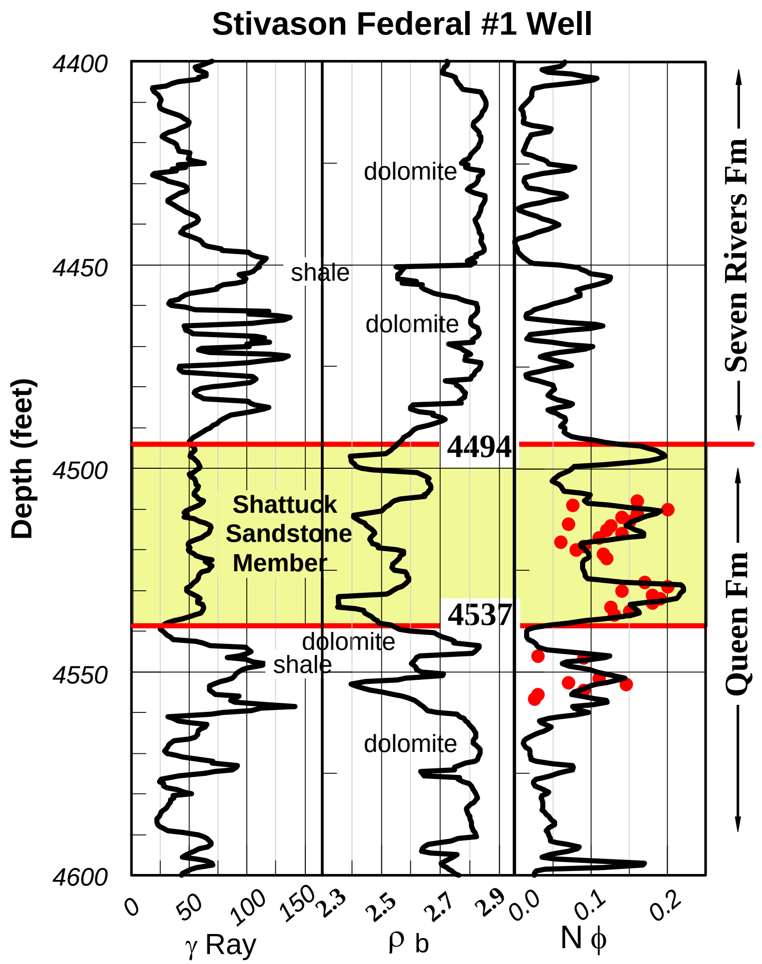
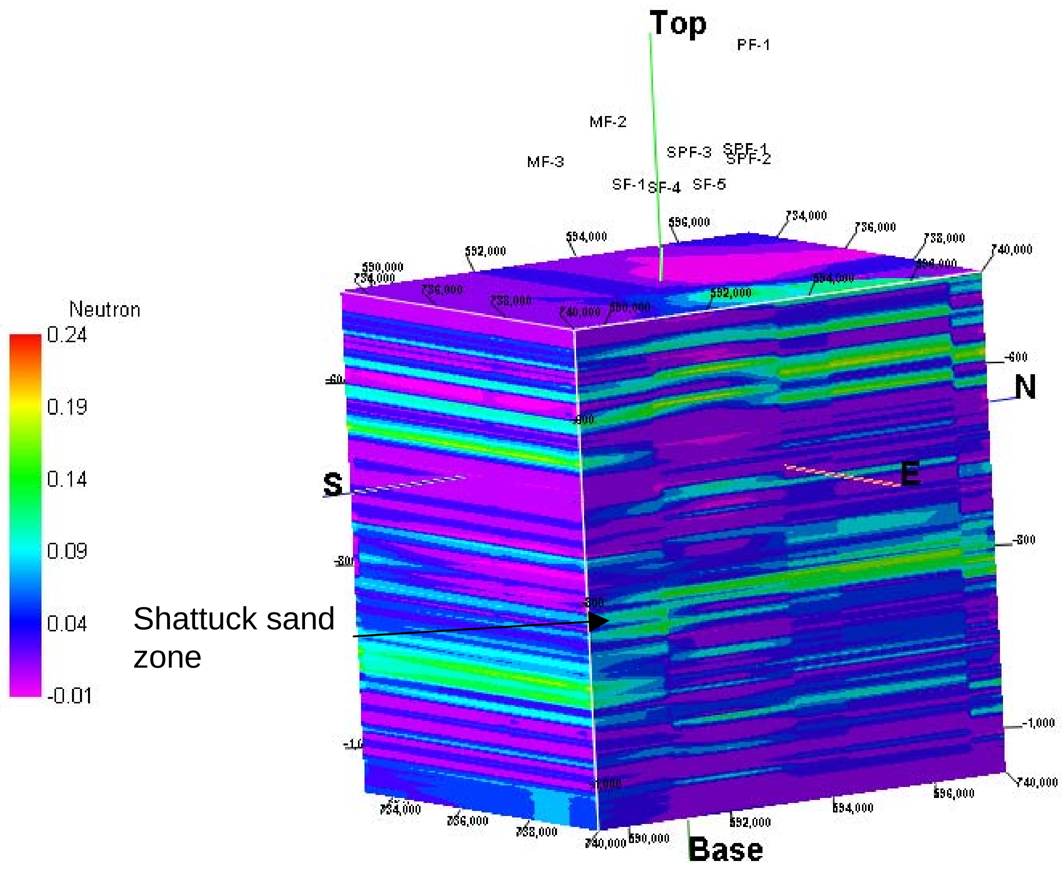


Figure : The gamma ray (γ), density (ρ) and neutron porosity (ϕ) logs are shown for the Stivason Federal #1 well. Core derived porosities taken from Westrich et al. (2001) are plotted for comparison on the neutron porosity log.



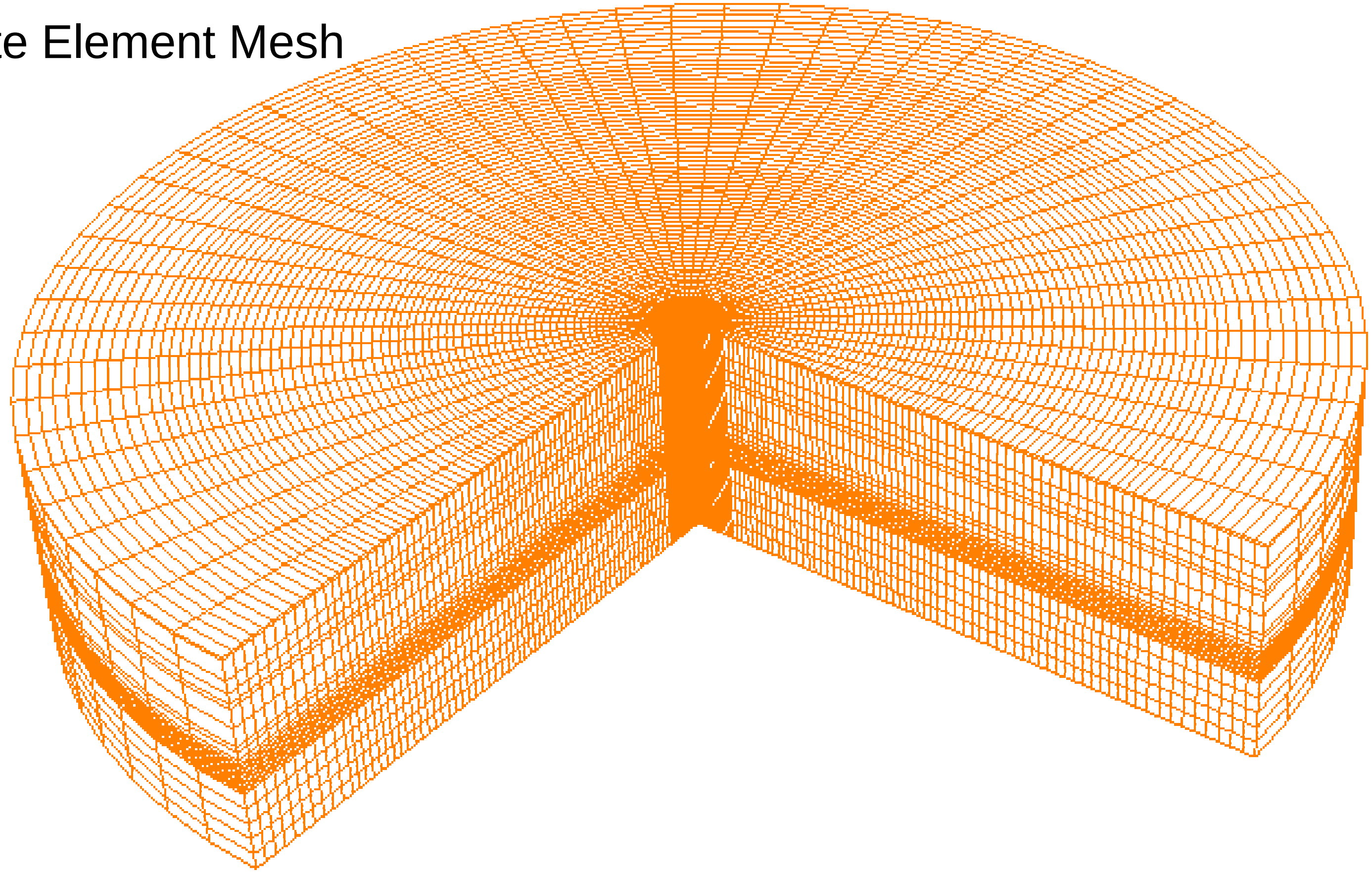
3D porosity model 6800 feet EW by 8000 feet NS - 600 feet thick.

2K-2571

Simulation Methodology

- Coupled flow-deformation formulation based on the theory of linear poroelasticity (Biot Theory).
- The numerical model was based on the finite element method.
- The injection of CO_2 in the porous medium was modeled by assuming single-phase flow.

Finite Element Mesh



- **Radius: 20,000 ft**
- **Height: 8,000 ft**

Methodology

- **Flow simulation was informed by characteristics of field test:**
  - Injection pressure (bottom hole): 2,900 psi
  - Duration of injection: 53 days
  - Total CO_2 injection: 2,090 tons
  - Reservoir pressure after the injection: 1,700 psi

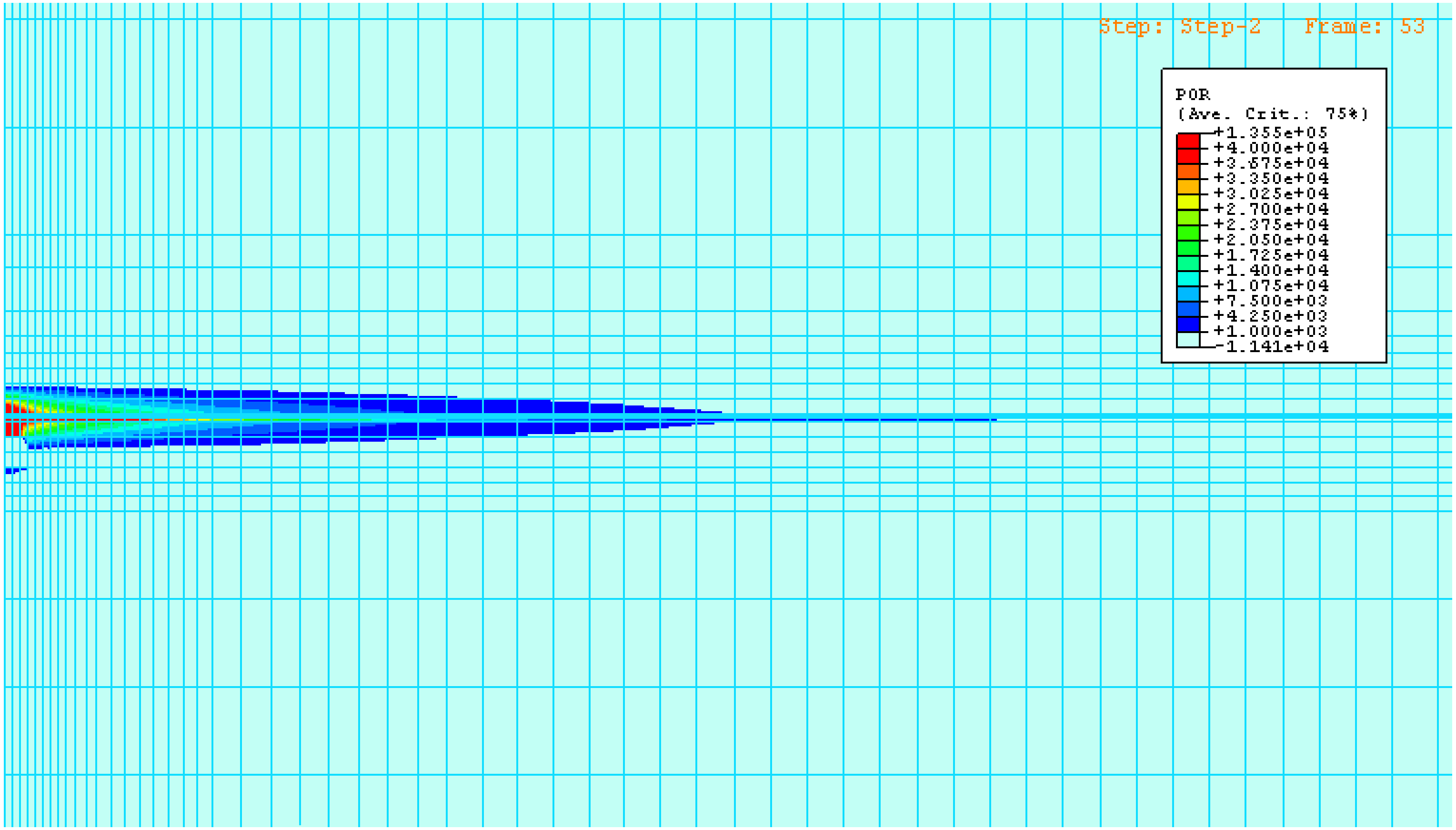
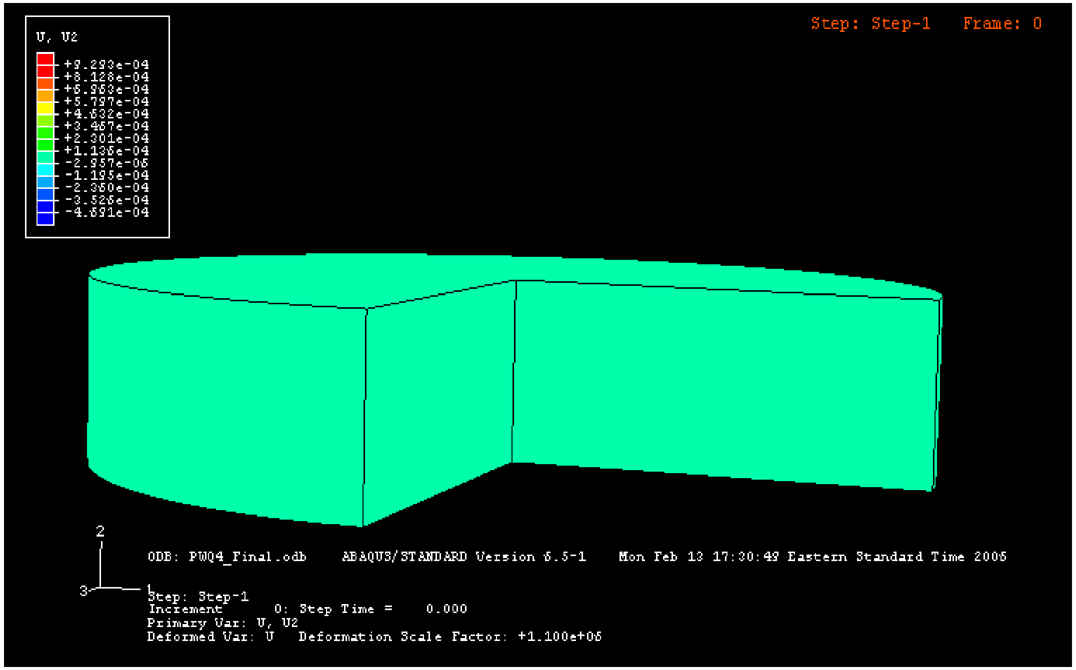


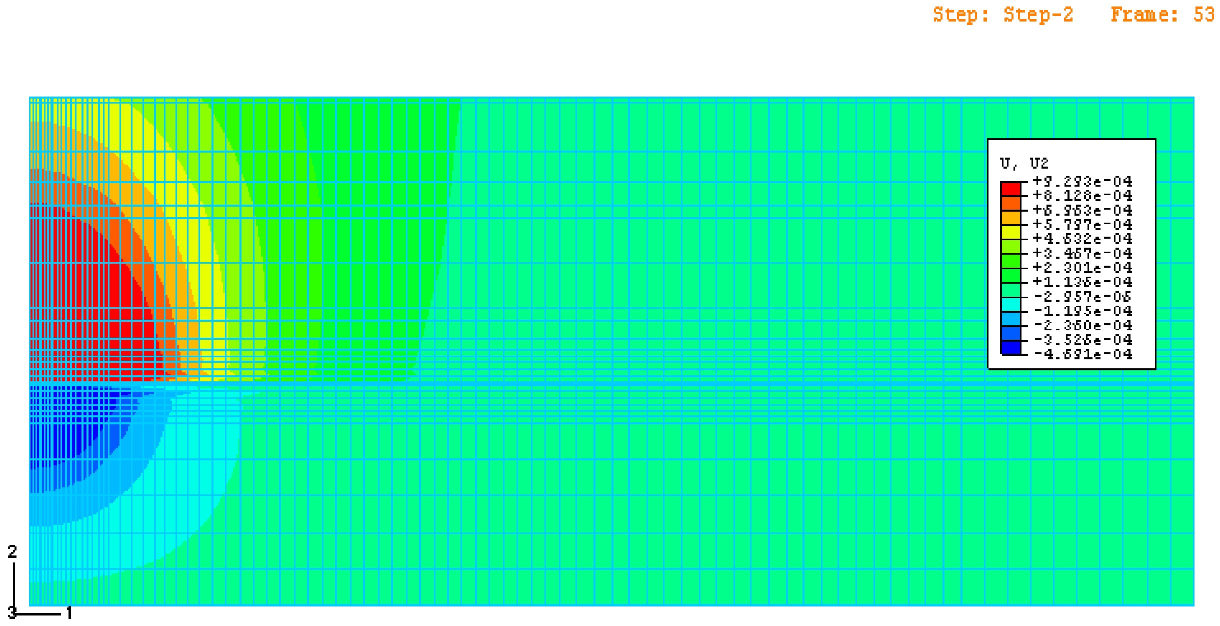
Figure 3: Computed Pores Pressure Distribution at 53 days

Pore Pressure

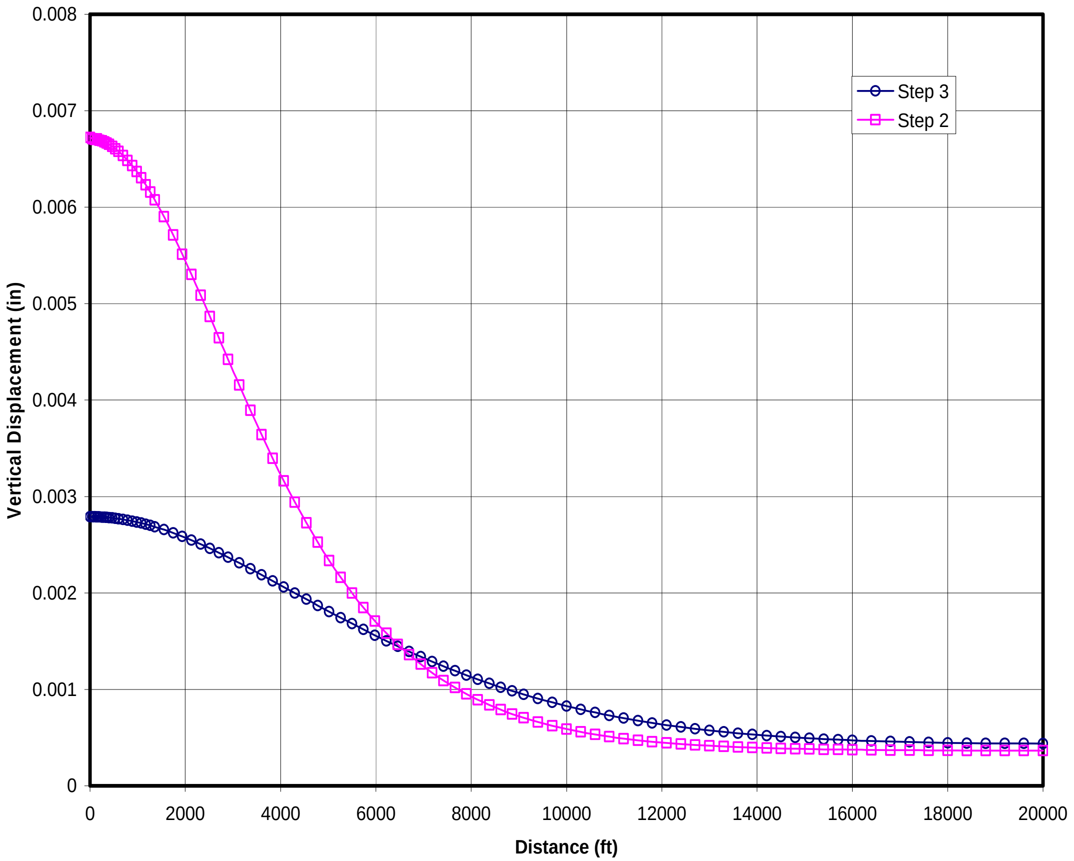
Vertical Displacement



Vertical displacements (ft)



Results


0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Vertical Displacement (in)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Distance (ft)
Step 3
Step 2

Discussion

- The results from the coupled flow-deformation analysis indicate that the ground surface deforms during and after the injection.
- While the magnitude of the ground deformations in this pilot test are very small, the results show the possibility of heaving of the ground depending upon the amount of CO_2 injection.
- Ground deformations and the surface slopes, which may be measured by tilt meters, could be used as an indirect method for monitoring of the CO_2 plume propagation.
- Underground measurements such as tilt meter measurements could be very useful during the monitoring phase.

Discussion (cont.)

- Fluid pressure measurements at observation wells within the reservoir and/or surrounding permeable formations could provide information useful to identifying the extent of the CO2 plume within the reservoir, as well as potential leakage pathways.

- The pressure decline data as well as measured surface deformations could be used to adjust the engineering parameters used in the analysis.

- The permeability and elastic properties of the geologic formations would have a significant influence on the reservoir response after the injection.

Conclusions

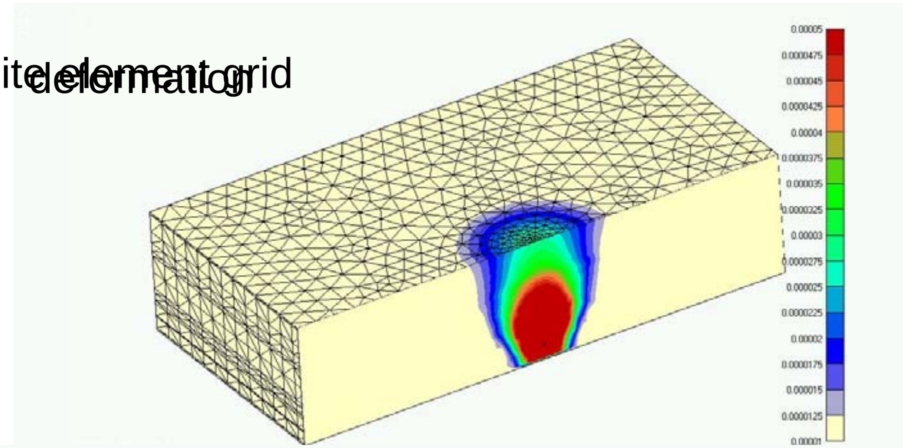
- Accurate geologic characterization of the sequestration site and determination of engineering properties are important issues for the reliability of model predictions.
- Therefore, a comprehensive effort on site characterization should be undertaken at any potential CO_2 sequestration site.
- Field monitoring of surface deformations and slopes together with underground measurements such as the pore pressure can be useful in fine-tuning computational models.

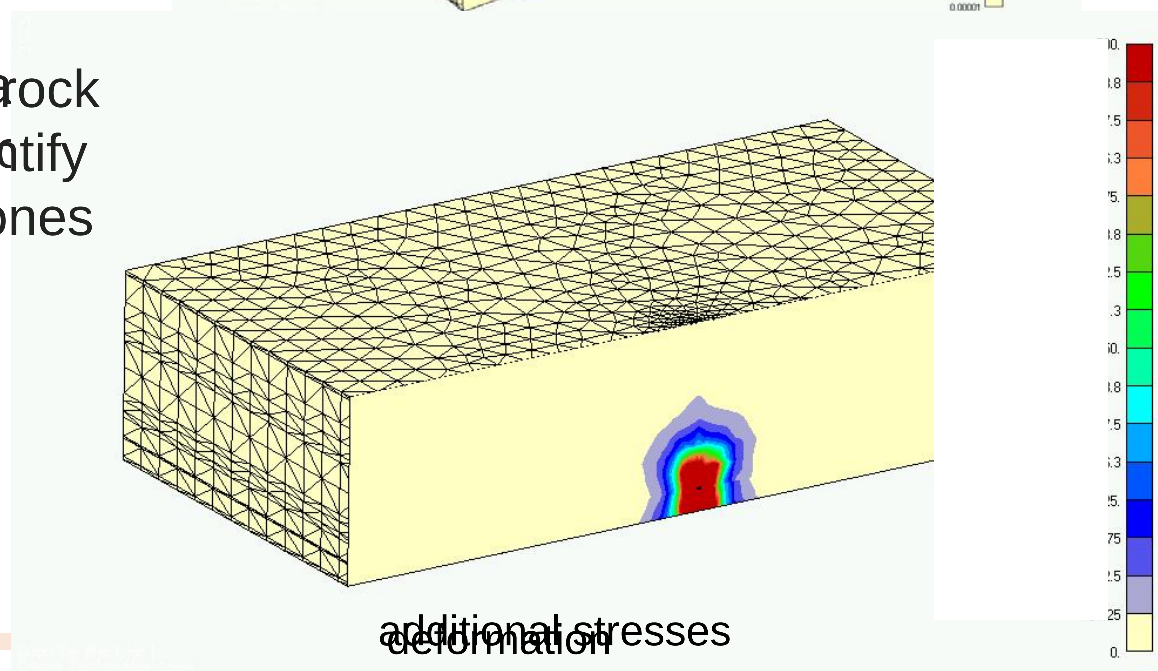
THANK YOU!

- **Elements: coupled displacement and pore pressure, 8 nodes in each element for displacement, 4 contained pore pressure**

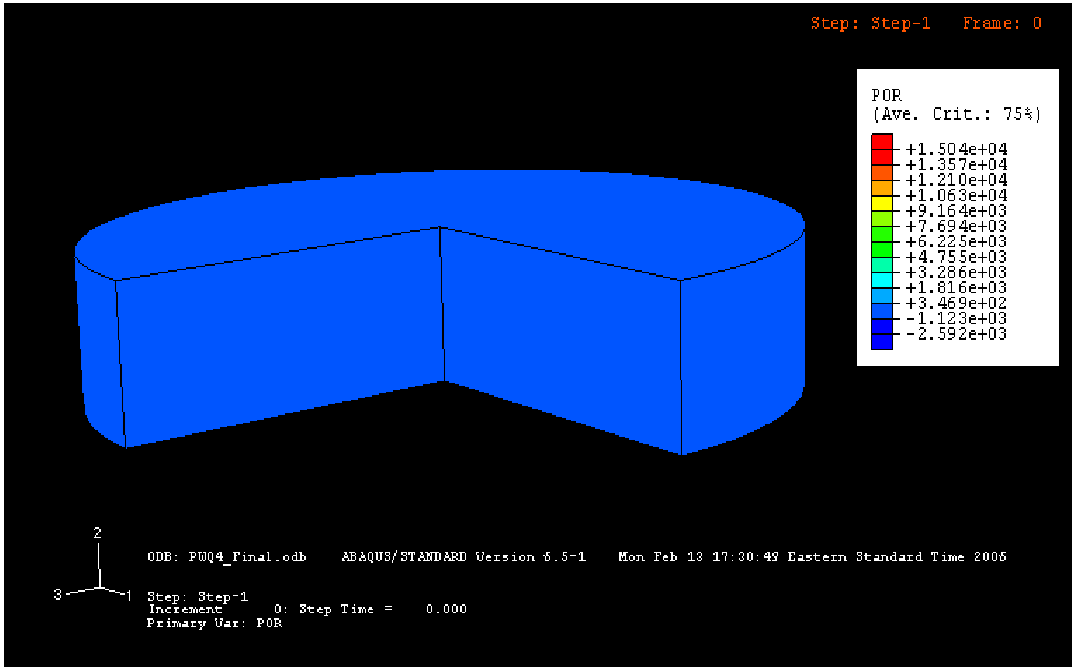
The SEQURE™ geomechanical model has shown deformations.

- **The finite element analysis allows us to:**
  - Study the potential surface deformation (tiltmeters)
  - Estimate internal rock stresses, and identify high pressures zones



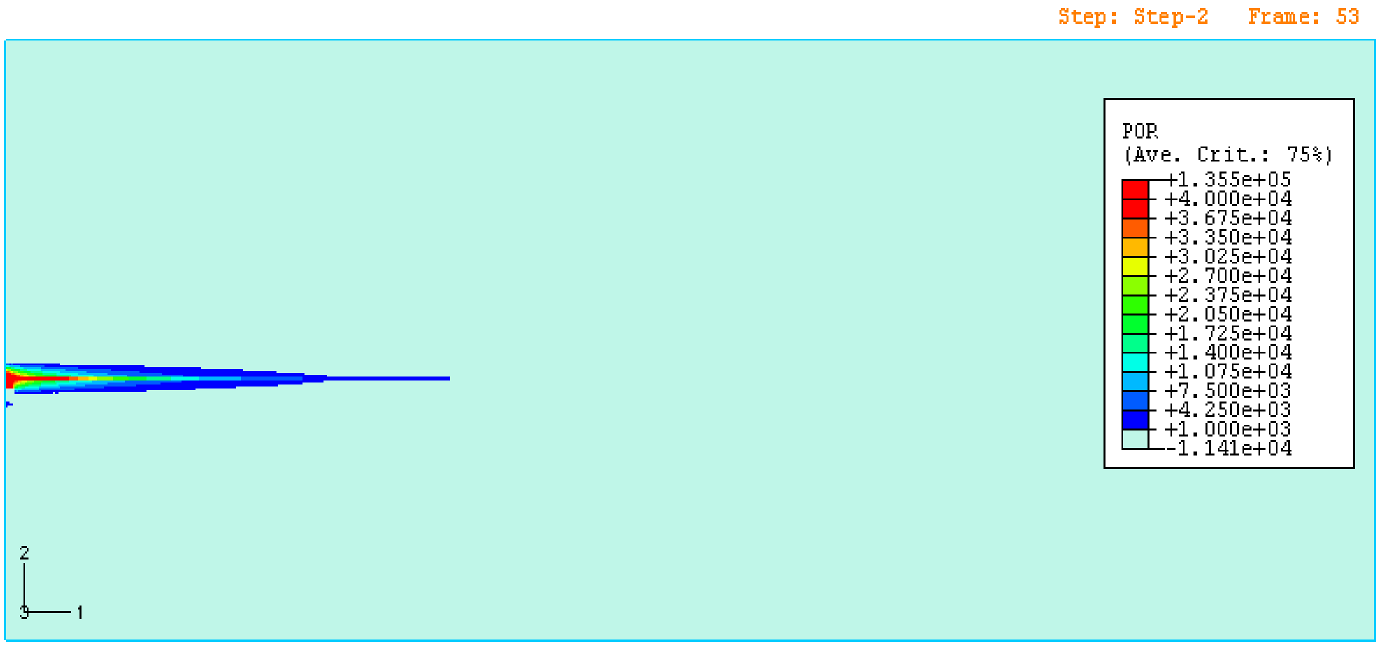


Pore Pressure

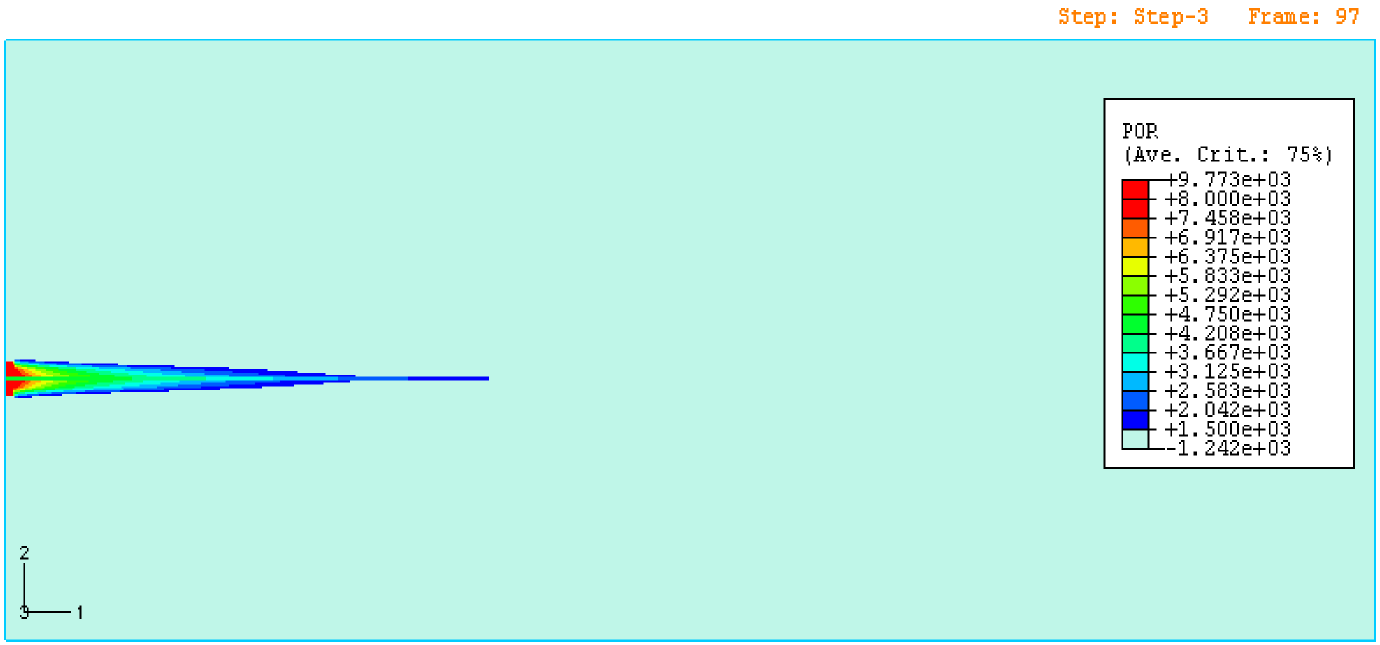


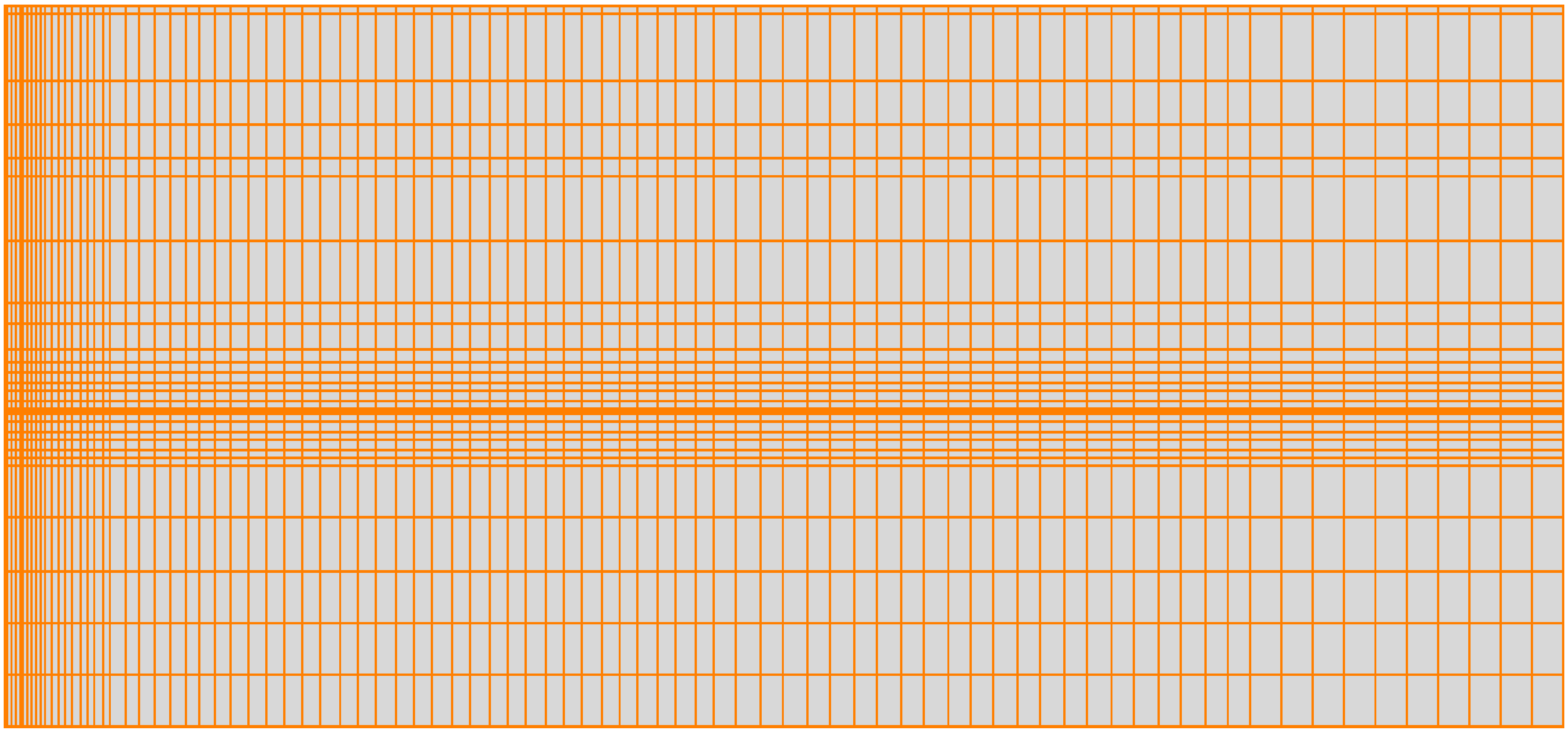
Vertical Displacement

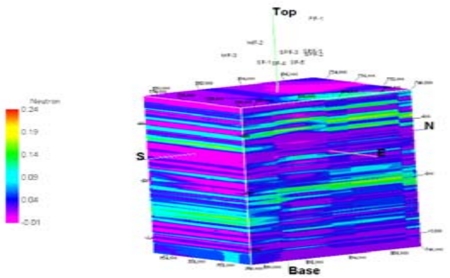
Pore Pressure at the end of Step 2



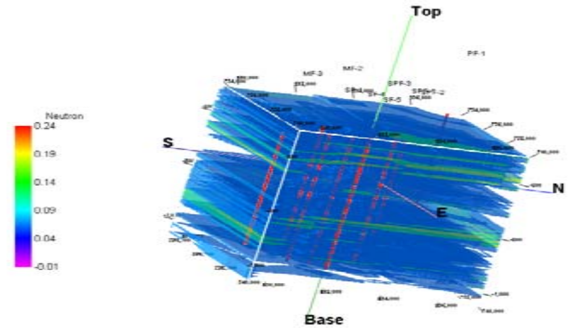
Pore Pressure at the end of Step 3



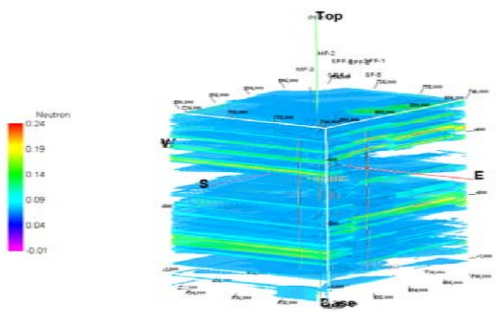




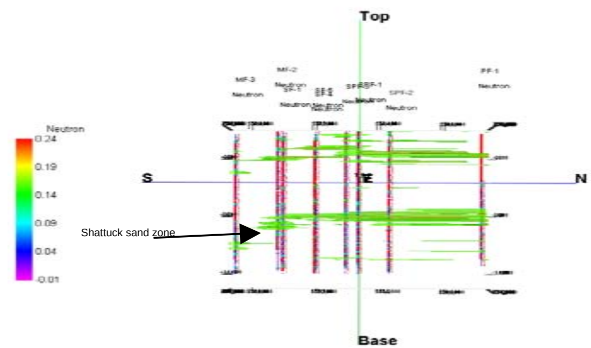
3D solid model 6800 feet EW by 8000 feet NS.
The model is 600 feet thick.



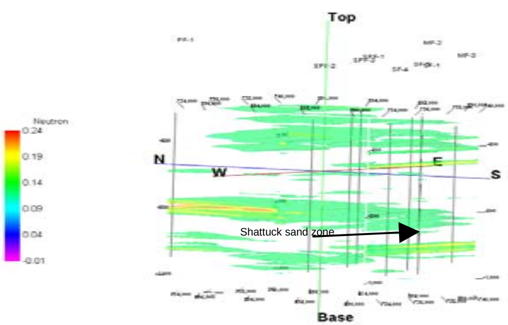
Transparency with 5% to 20% porosity zones highlighted



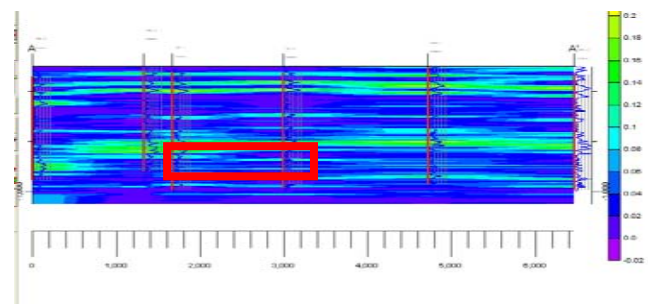
Another view



Greater than 13% porosity



10% porosity and greater and greater



The rectangular area above extends from the Stivason #4 well to the Stivason #5 well. The greens to yellows in the highlighted interval are the higher porosity zones within the Shattuck.

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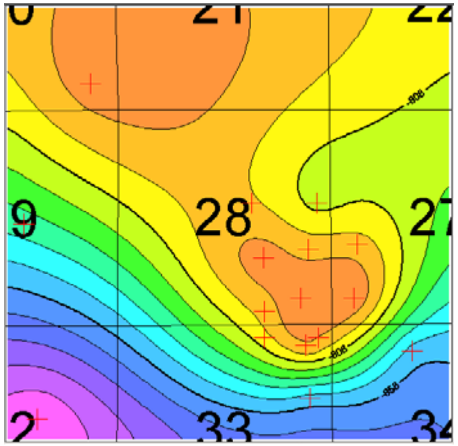
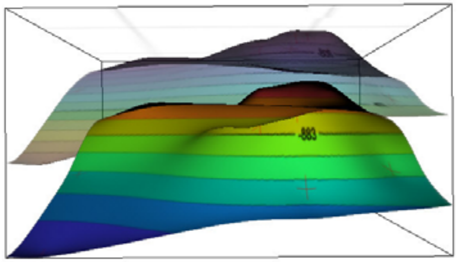
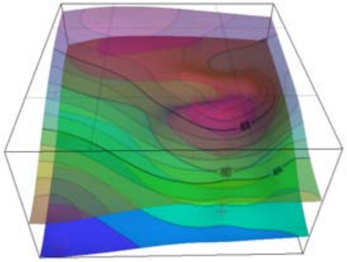
Contour and 3D Perspective Views of Injection Zone Structure



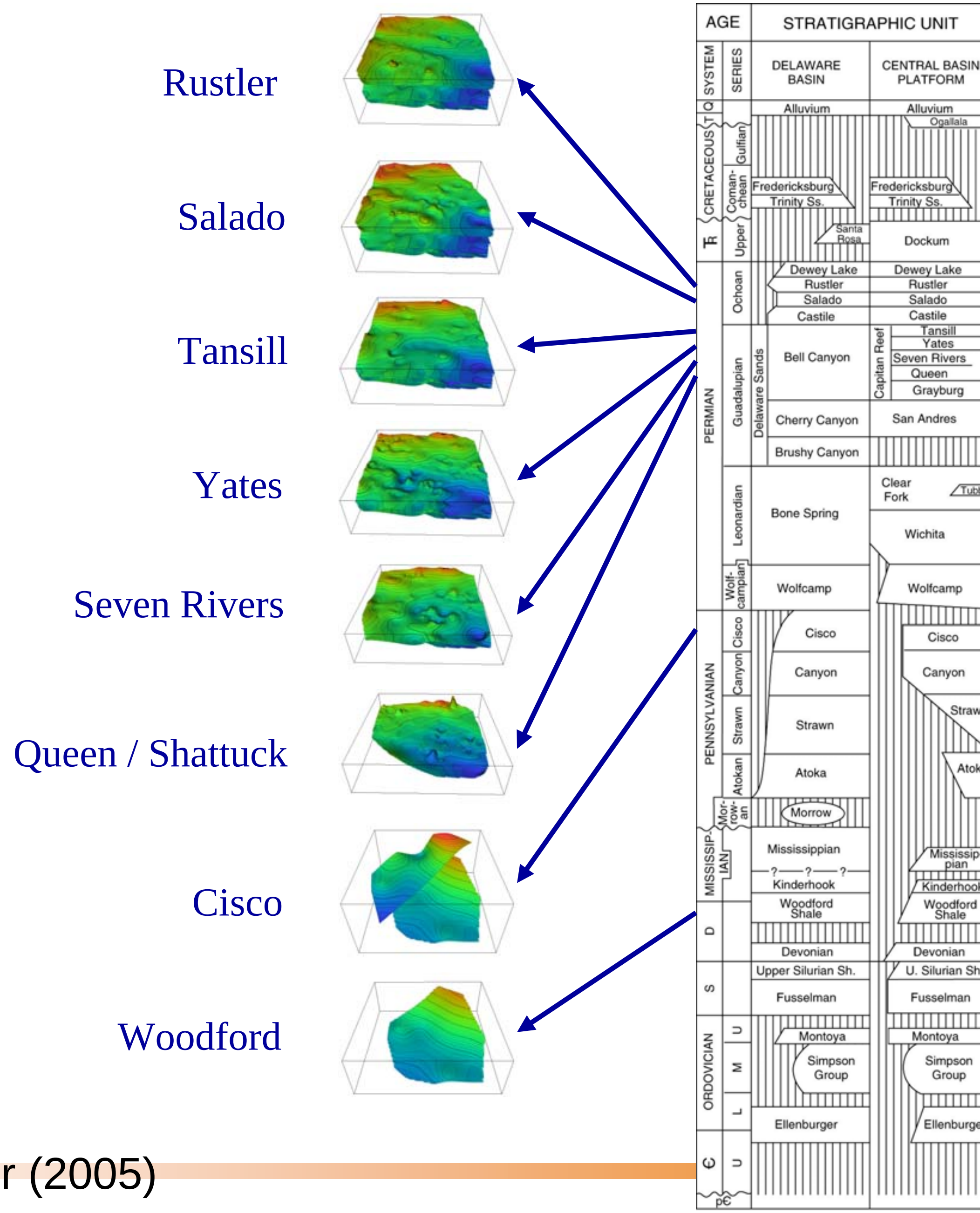


From Carpenter (2005)



Infill – carbonates, evaporites, tidal flat …

Basin Subsidence



From Carpenter (2005)