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The Business of Innovation

MRCP Phase III Overview

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Regional Carbon Sequestration Partnerships Initiative Review Meeting
October 6-8, 2008, Pittsburgh, PA

NETL
U.S. Department of Energy/NETL

MRCSP Phase III Sites

Primary site

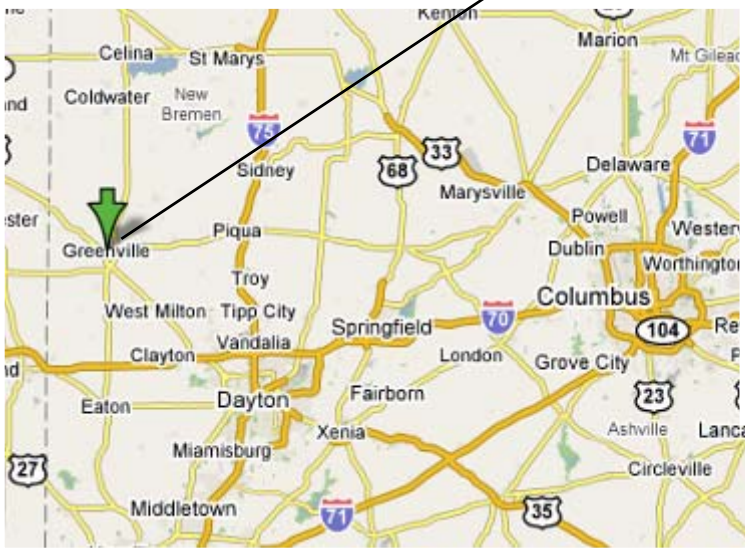
- **Host:** TAME, a joint venture of The Andersons and Marathon Petroleum
- **Plant operational:** February 2008.
- **Injection start:** FY2010
- **Scale:** 1 million tonnes of CO_2 over a four-year period
- **Target:** Mt. Simon at ~3300 ft.

Optional site

- **Host:** Duke Energy
- **Plant operational:** FY 2012
- **Possible injection start:** FY 2012
- **Scale:** Possible 2 million tonnes over four-year injection period
- **Target:** Mt. Simon at ~8000 ft.
  - Multiple injection zones and caprock layers

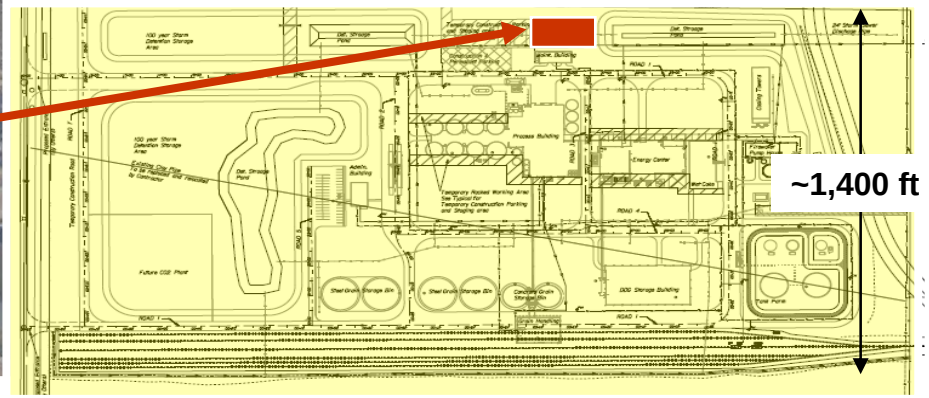
MRCSP
MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

Location of TAME Site



Surface Infrastructure

TAME Ethanol Plant Site



CO_2 Vent Stack

Compression and Dehydration

Injection Well

Meetings with public officials and the public have occurred over the past year or more in Greenville

Public Meeting in Greenville, August 13, 2008

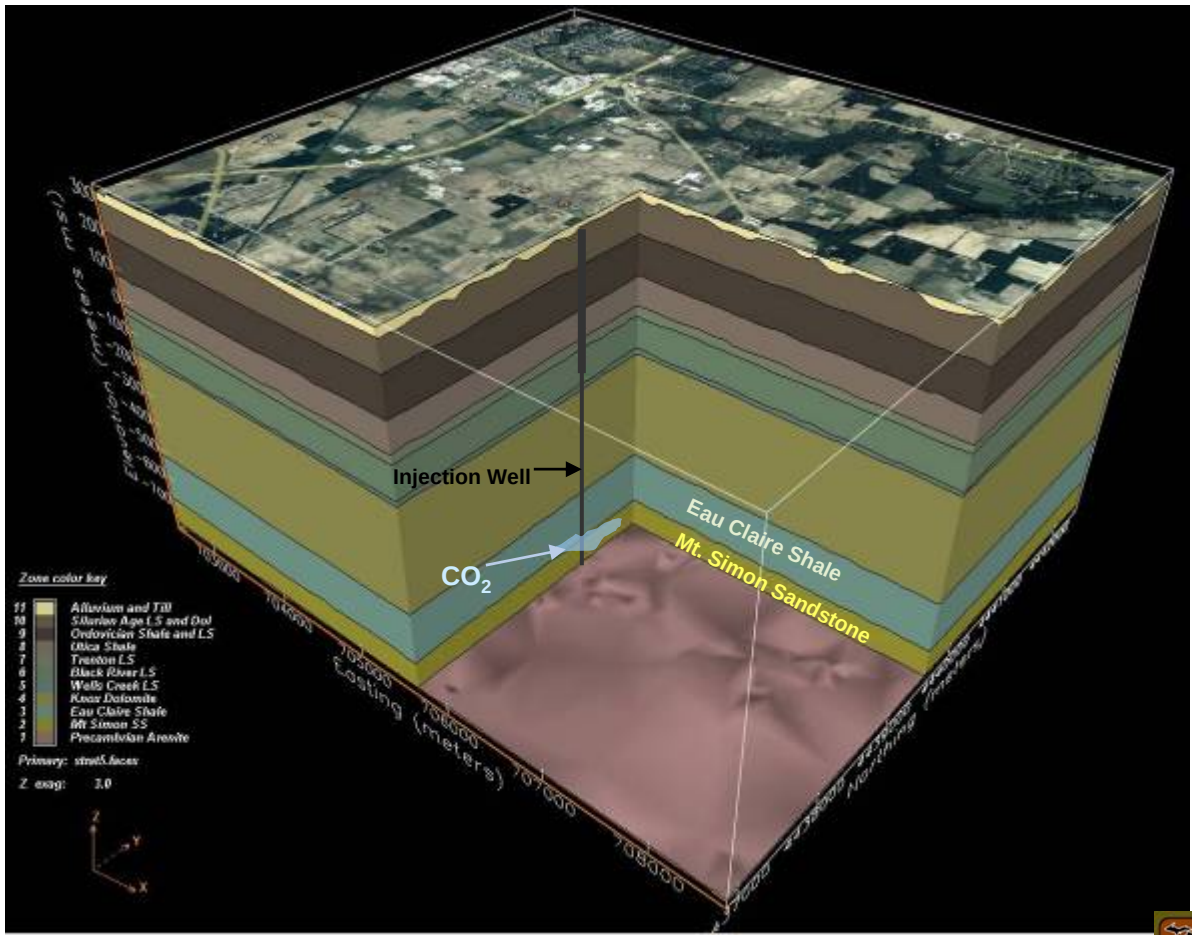
Community leaders: Project appears good for community image. May help with jobs in the future. But we need to know it is safe.

1) **What's in it for us?**
2) **Why do this test here in our community?**
3) **How can we assure that the CO_2 won't leak out? What happens if it does?**
4) **Will the CO_2 mobilize other things like methane, radon, etc.?**
5) **What happens if the CO_2 does get into drinking water supplies?**
6) **How do we know injection won't cause earthquakes here? How do we prevent that?**
7) **Who's going to pay if there is damage to the community now or in 50 years+**
8) **Seems like there is a lot of money to be made in carbon credits. Who gets that?**
9) **Lake NYOS. CO_2 can be deadly.**
10) **Why do we need CCS. Why not focus our effort on developing wind, solar, and nuclear.**

Phase III Site - Conceptual Model

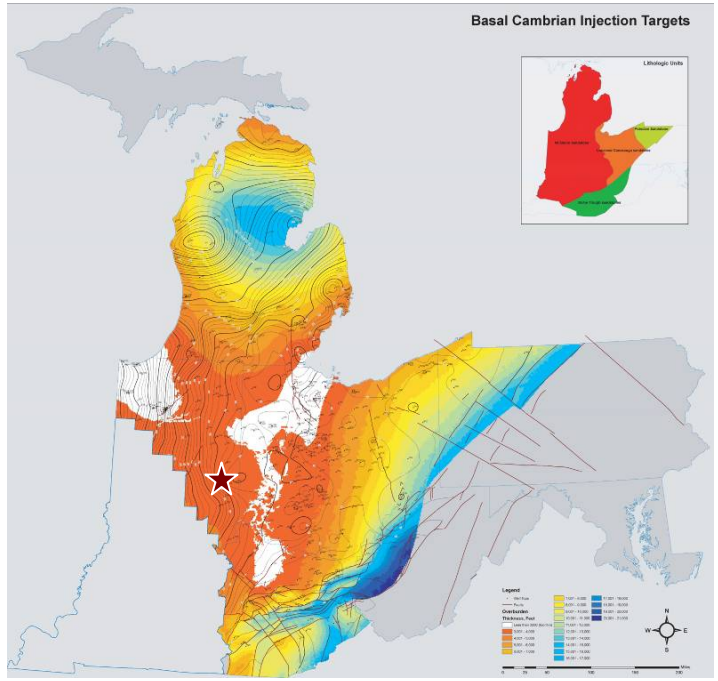
- Location = TAME Site, Darke County, OH
- Source = Ethanol Plant
- Land use = agricultural
- Geologic Setting = Ohio-Indiana Platform
- Storage Target = Mt. Simon SS (3300-3600 ft)
- Containment = Eau Claire Shale (2750-3300 ft)
- Injection rate = 282,000 metric tons CO2 per year
- Total injection = 1.1 million metric tons CO2 over 4 yrs

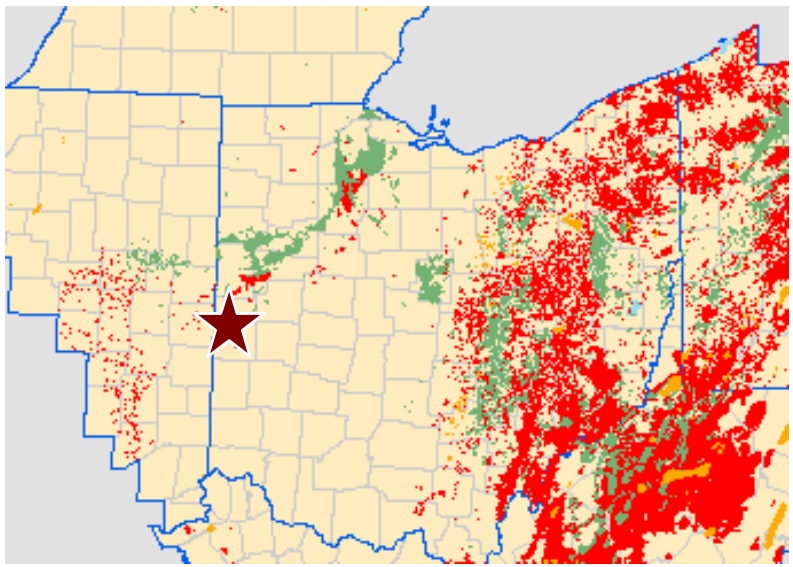
Conceptual Model



Geology- Framework

- Structural location = Cincinnati Arch
- Basal Cambrian sands/Mt. Simon – depth is the color grid –white where < 3,000'. The contours show the thickness (~300 ft at test site).

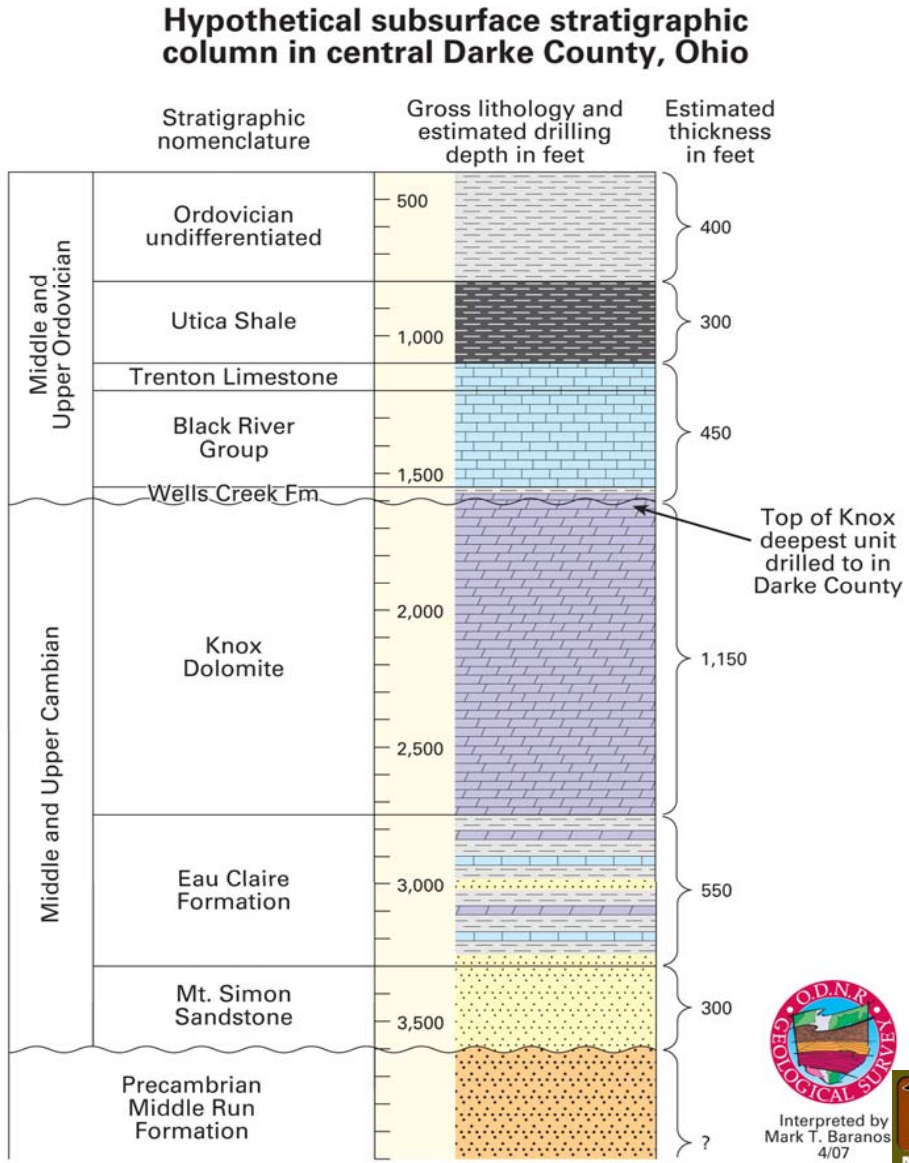




- Few deep wells near site.
- Not much oil and gas present present in area.

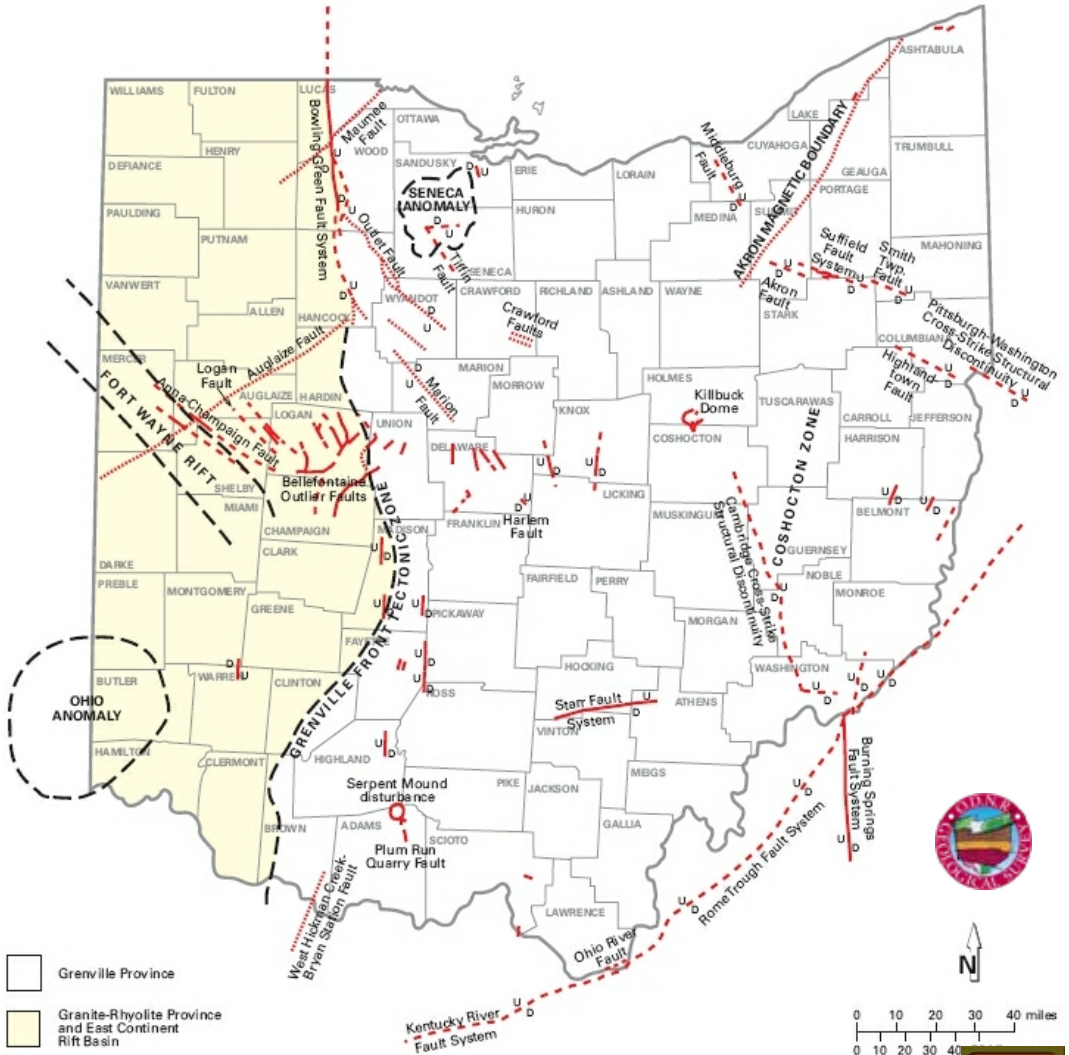
Geology and Permitting

- Mt Simon ~300 ft thick arenite sandstone in area.
- Eau Claire shale ~500 ft of confining layer
- Ohio EPA has advised this will be a Class I-nonhazardous permit
- NEPA Environmental Assessment is being prepared by DOE



Structural Setting - Faulting

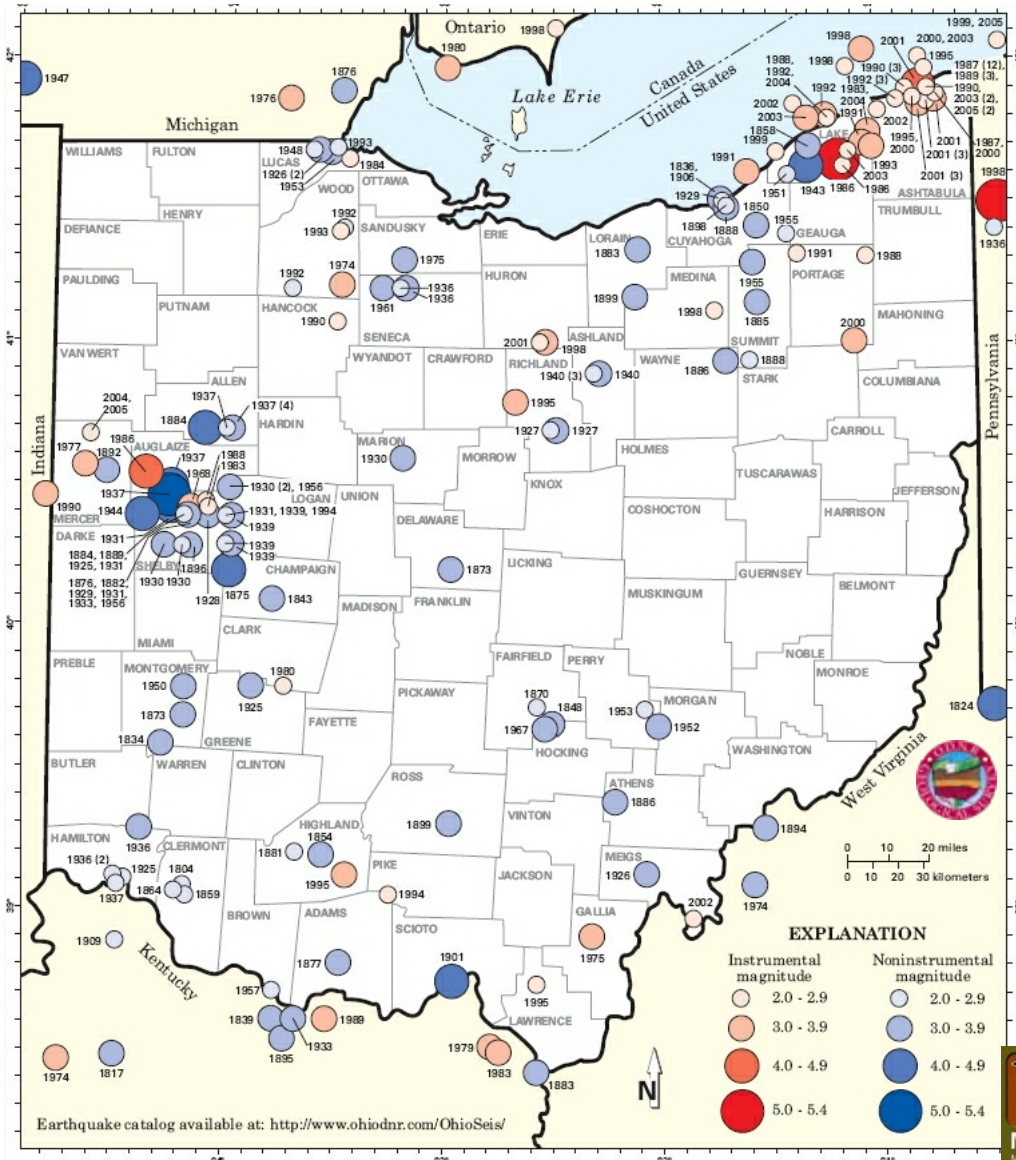
- Most faults in northwestern Ohio associated with Precambrian basement rocks at depths over one kilometer below land surface.
- There are no existing seismic surveys in the area. Therefore, it is not clear if the faulting in northwestern Ohio extends into Darke County.
- A seismic survey is planned as the first field activity in site characterization



Basement structures in Ohio (modified from Division of Geological Survey Map PG-23, 2002). This map portrays a number o and other structures that have been identified by a variety of geologic studies. Some faults are well known, whereas others ar Very few of them are visible at the surface. The Fort Wayne (Anna) rift in western Ohio is the site of numerous historic earthq

Seismic Activity in Ohio

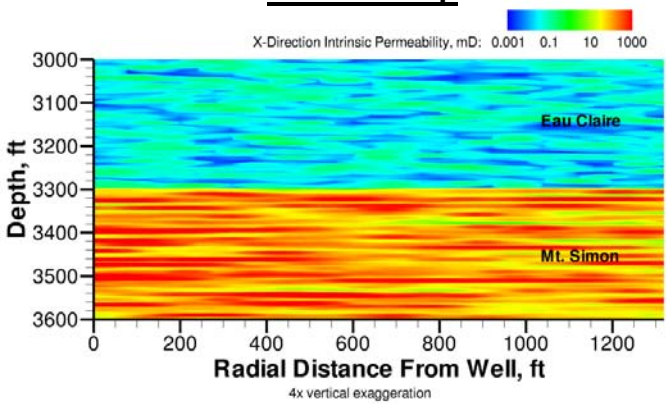
- Seismic activity map of Ohio shows no events in Darke County despite its proximity to Anna Seismic zone

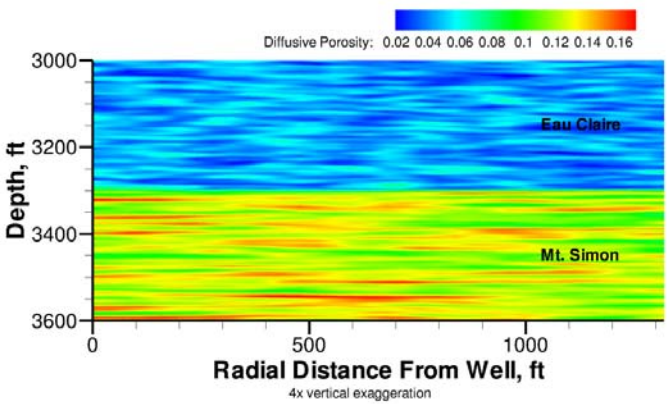


Preliminary Reservoir Simulations

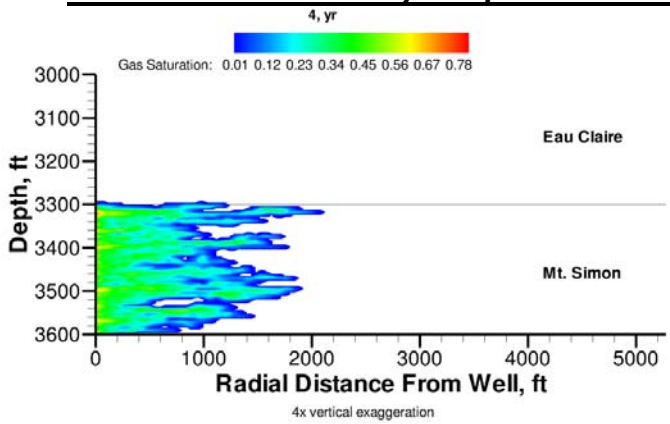
- Preliminary reservoir simulations for TAME site were completed based on data from Class I wells in western Ohio using STOMPCO_2
- Results suggest CO_2 extending ~2,000 ft for single vertical well

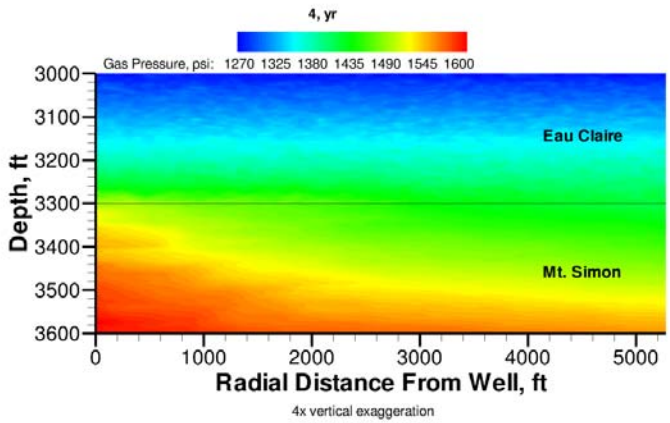
Model Setup





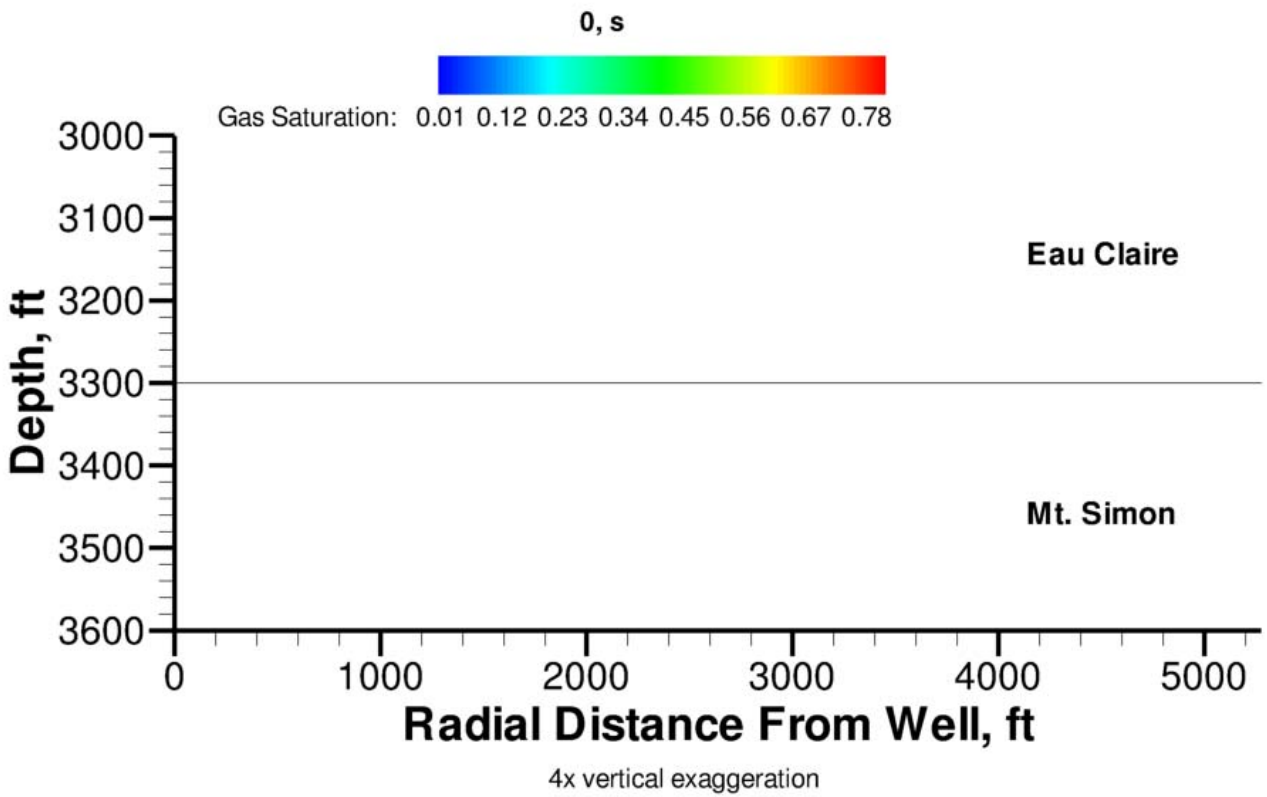
Model Results after 4 yrs Injection 280kton/yr





Note- these are preliminary simulations based on regional datasets. More specific modeling will be performed once more site characterization data is available from the test well.

Preliminary Reservoir Simulations – CO_2 Spreading



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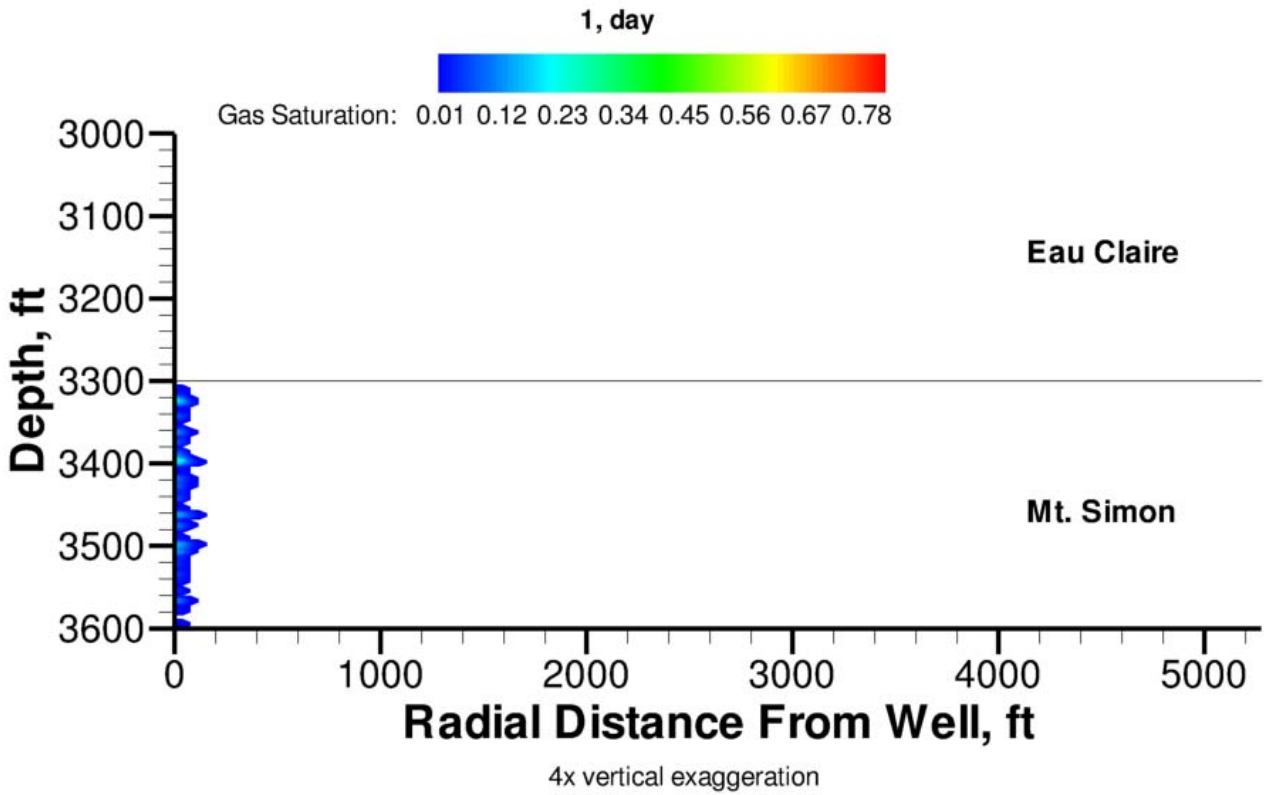

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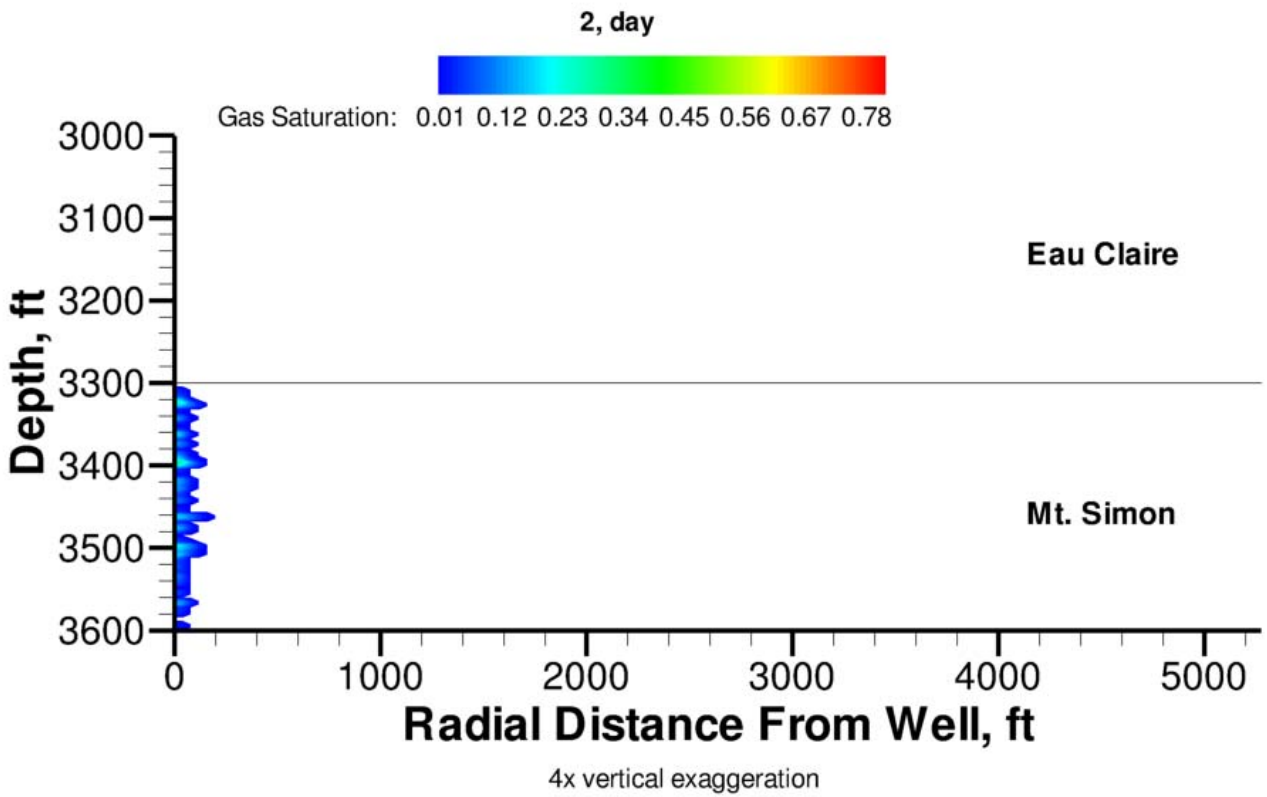

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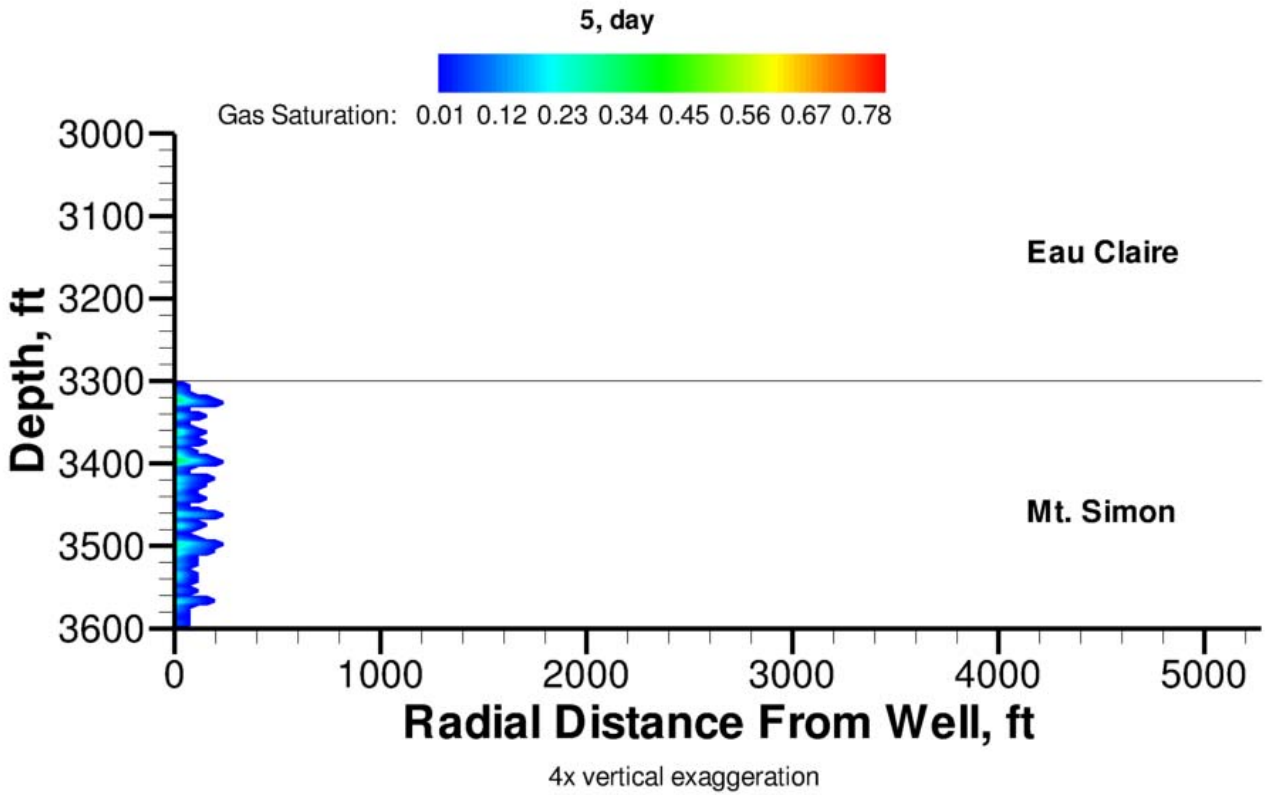

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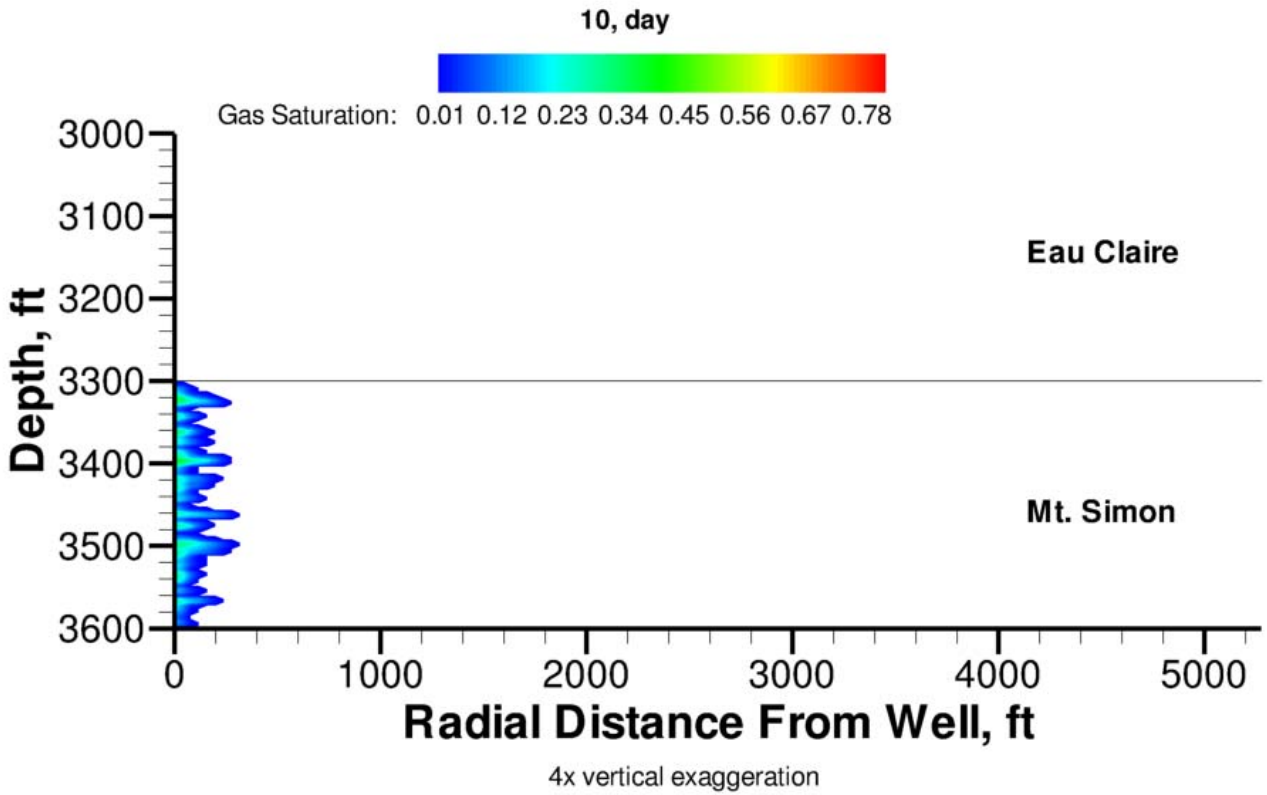

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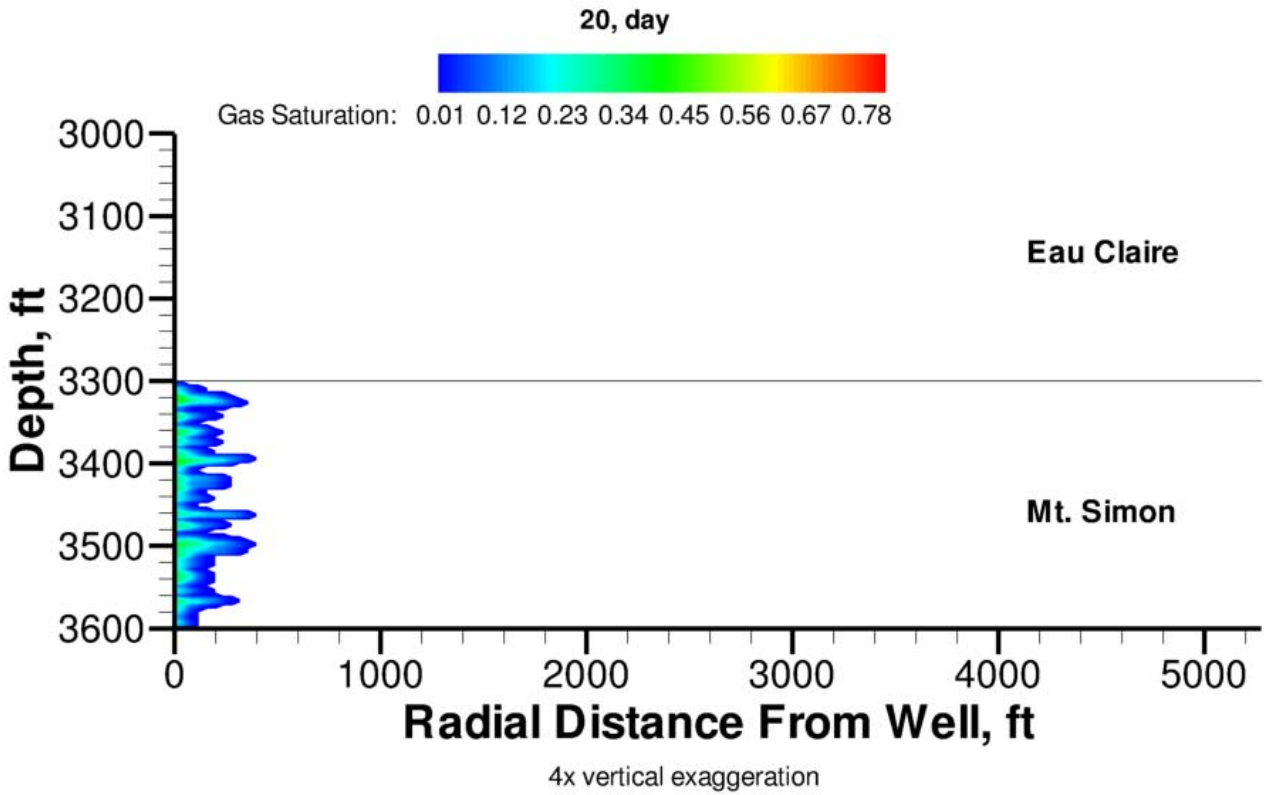

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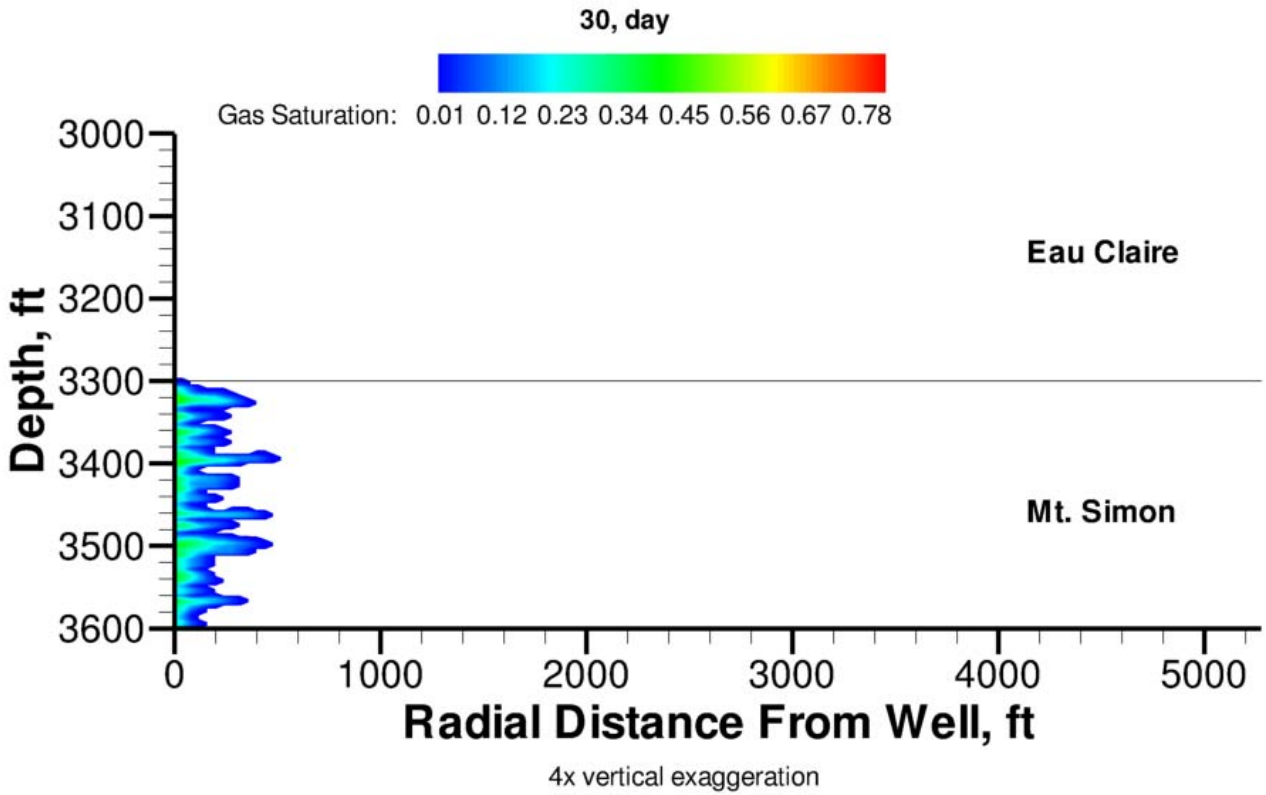

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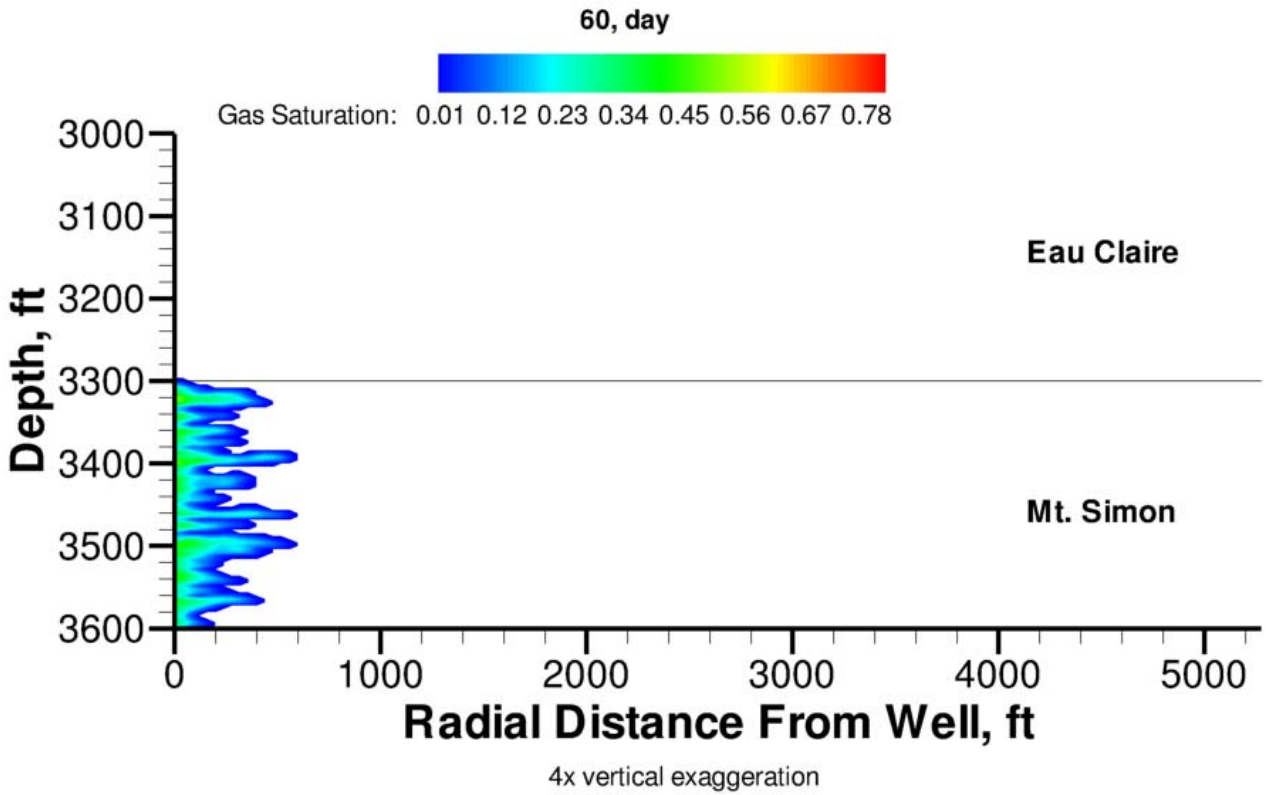

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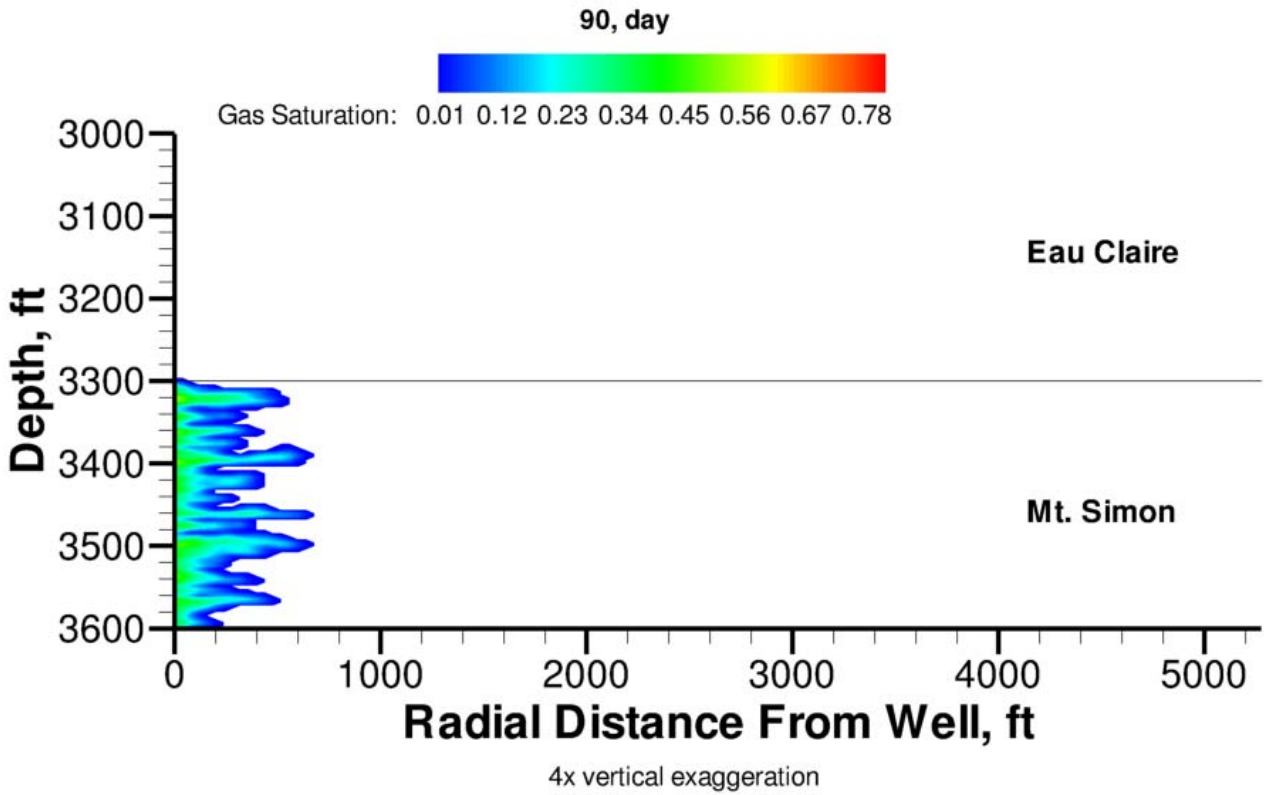

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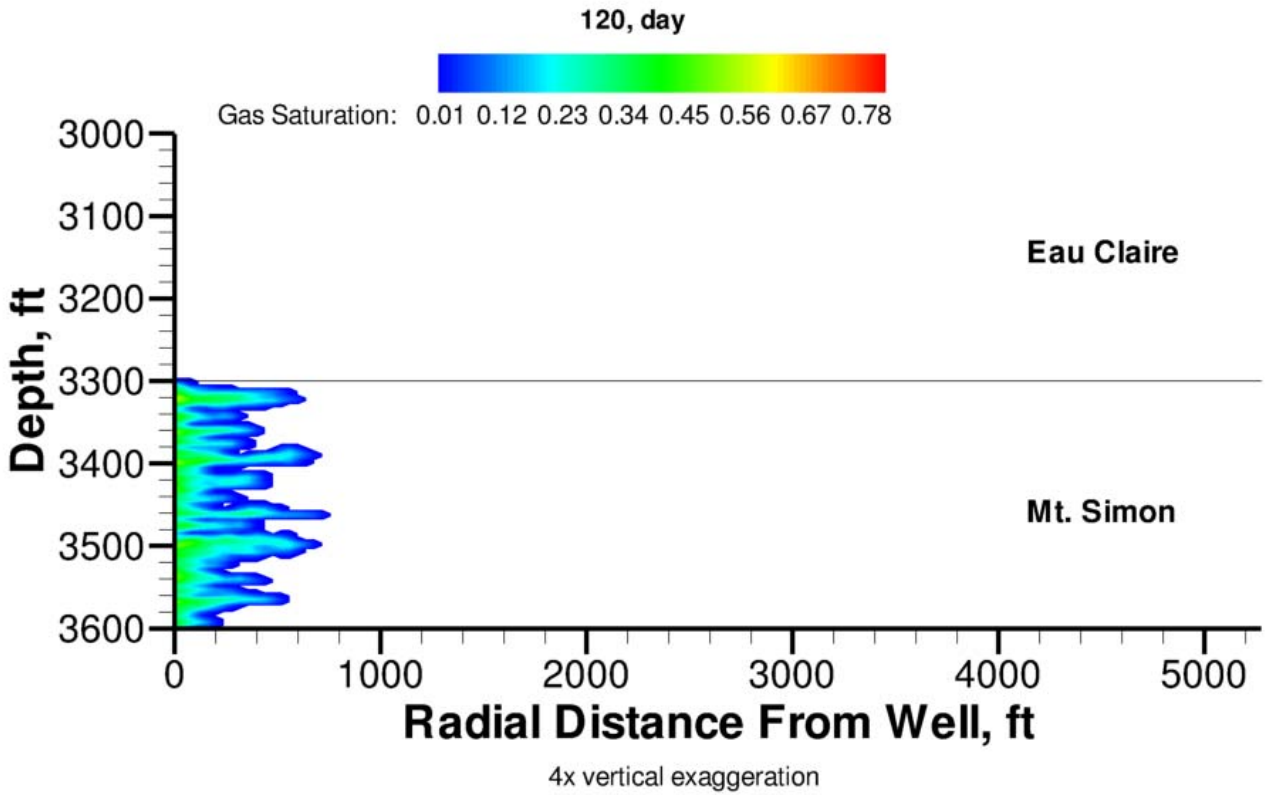

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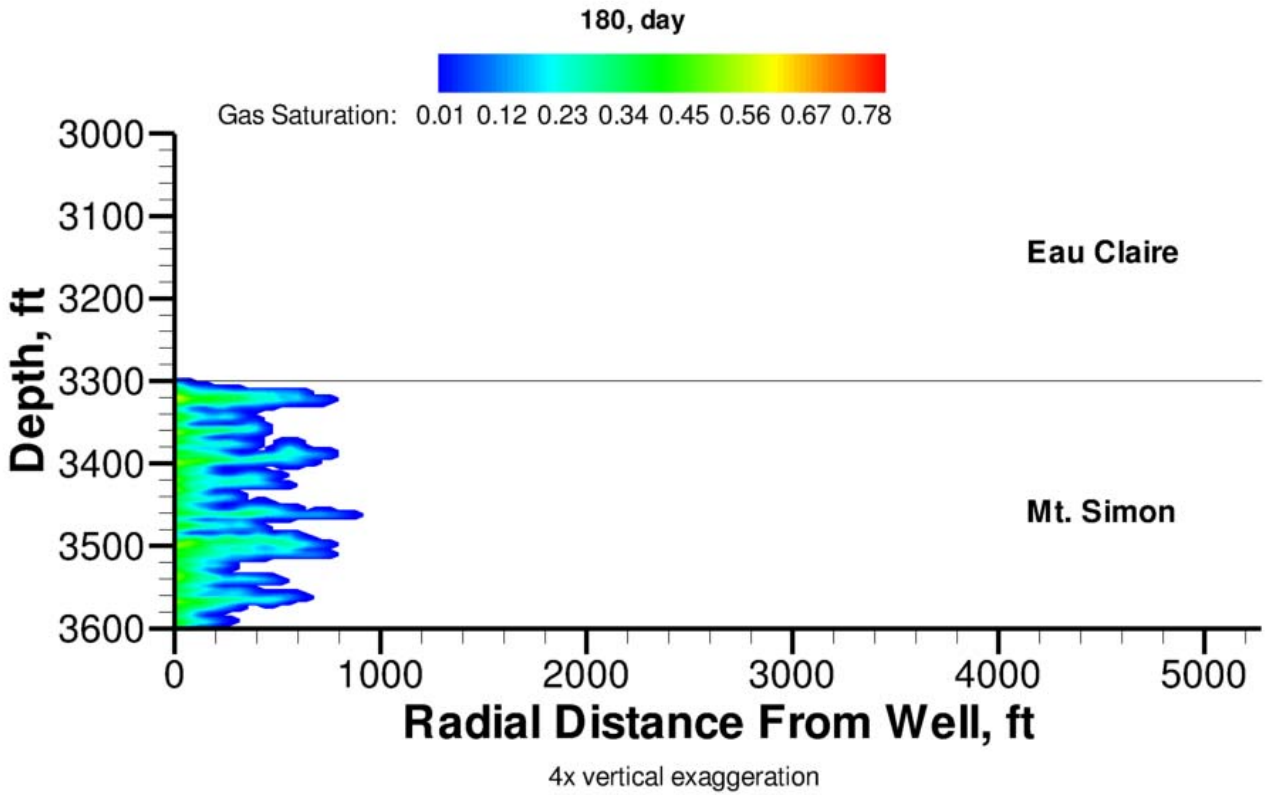

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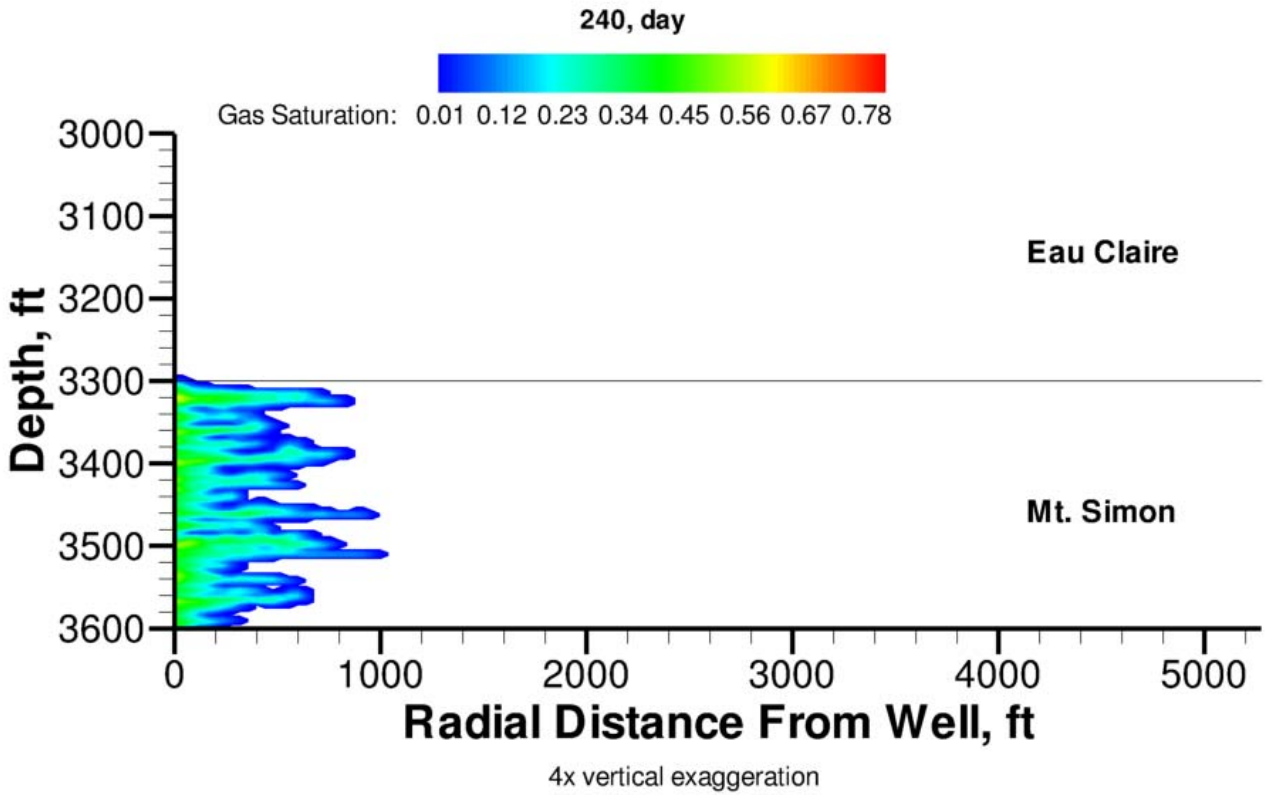

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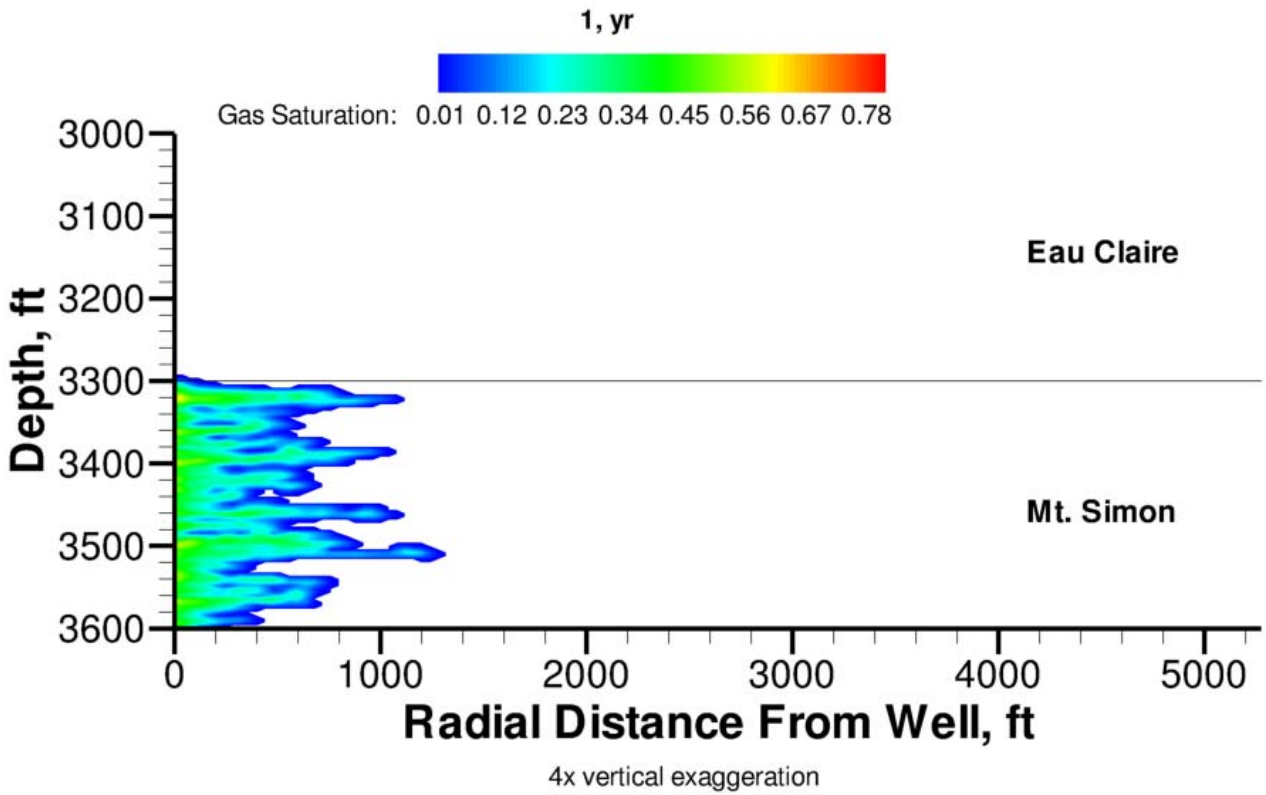

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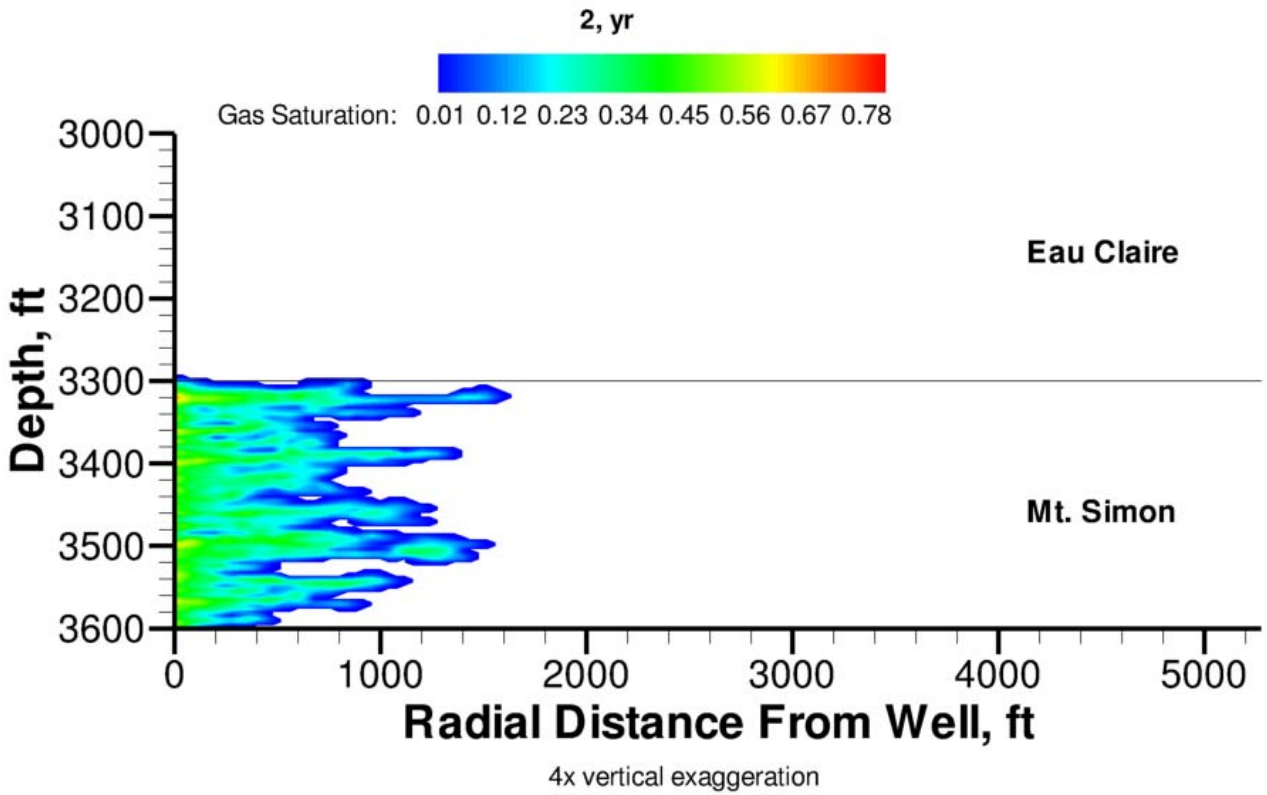

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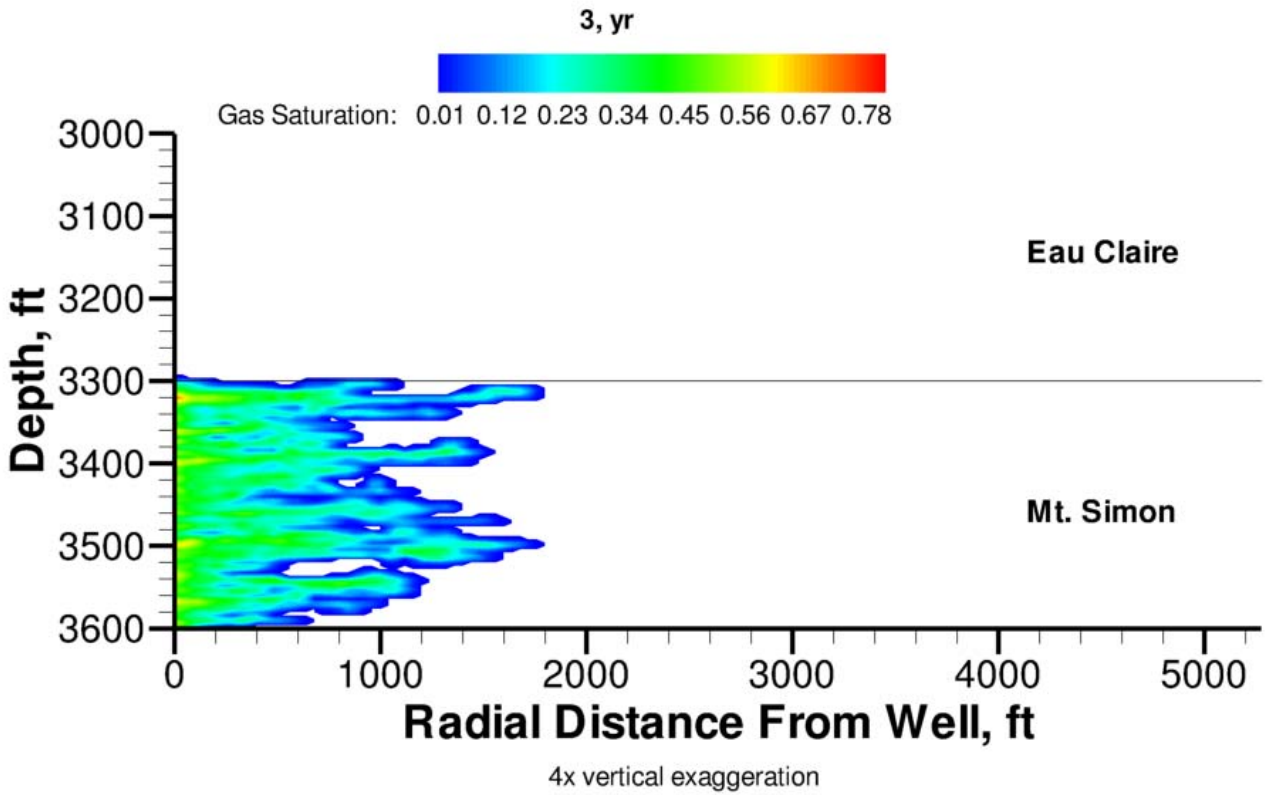

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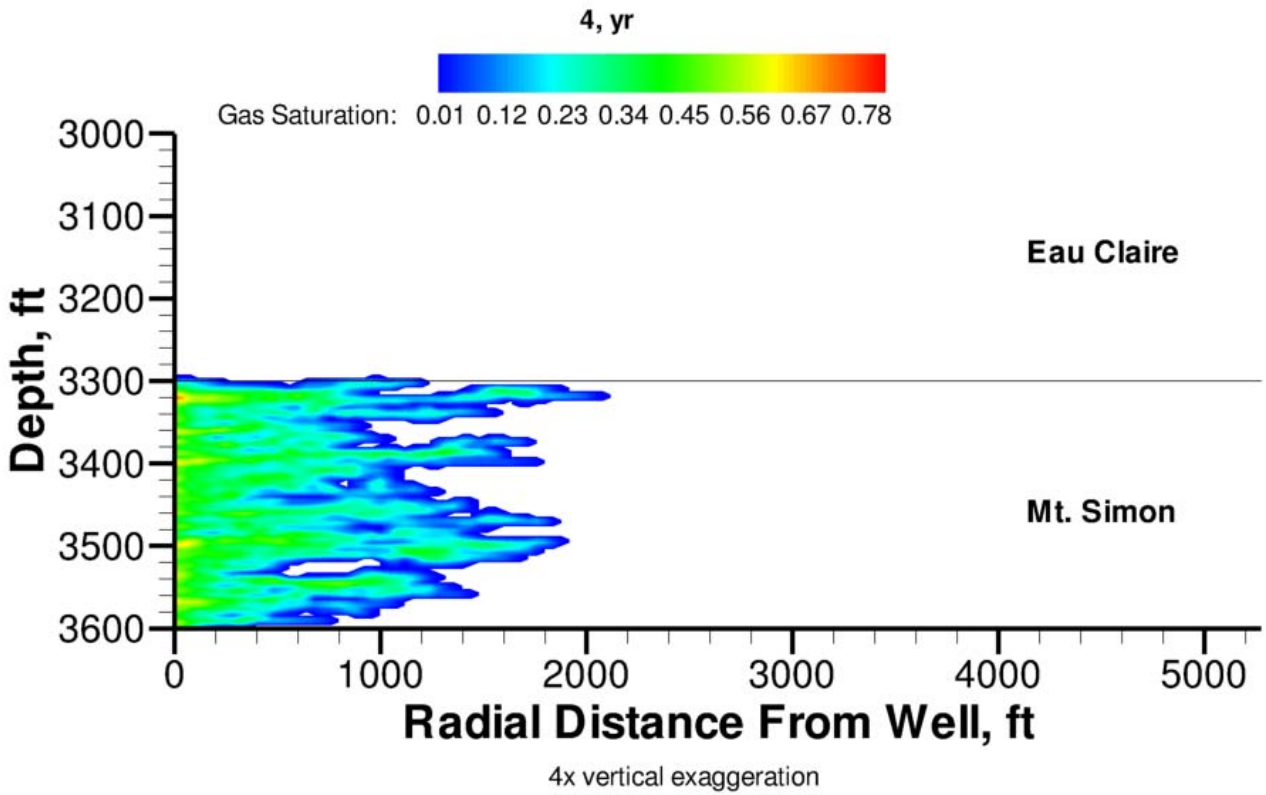

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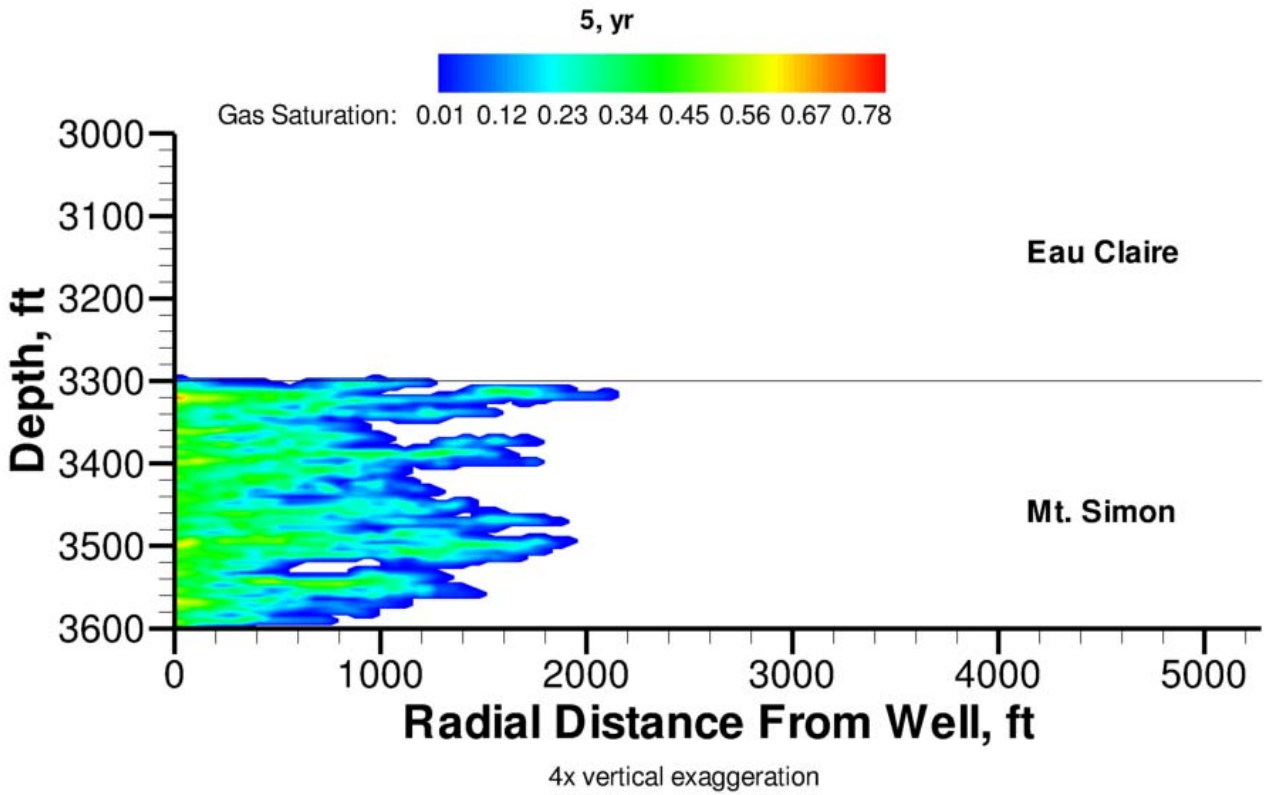

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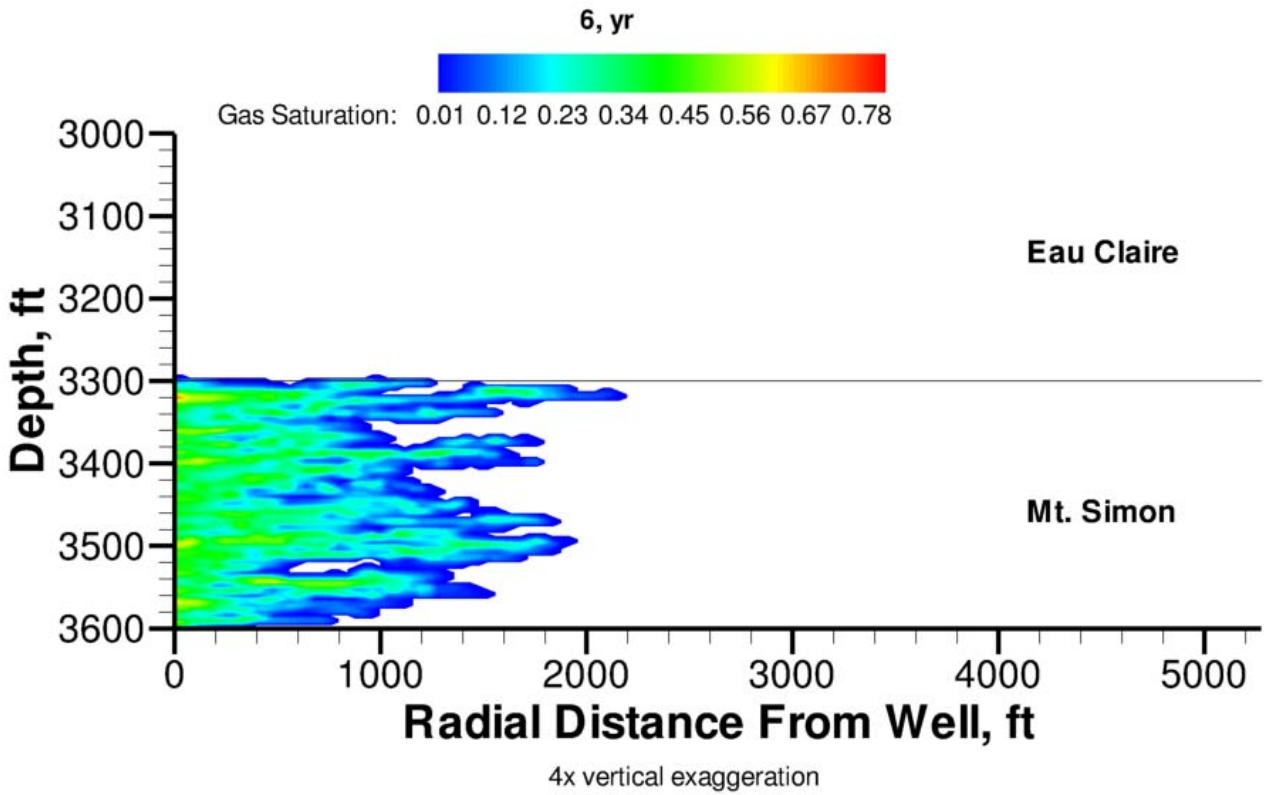

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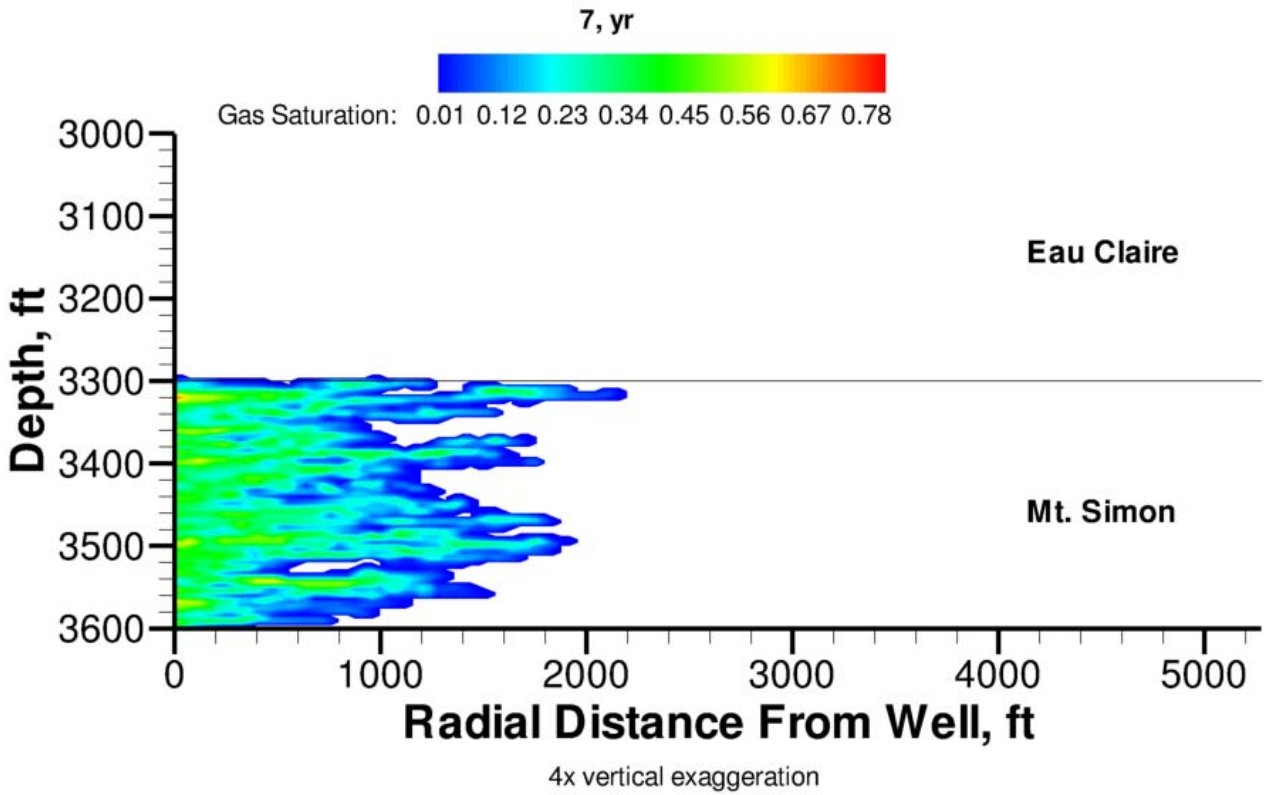

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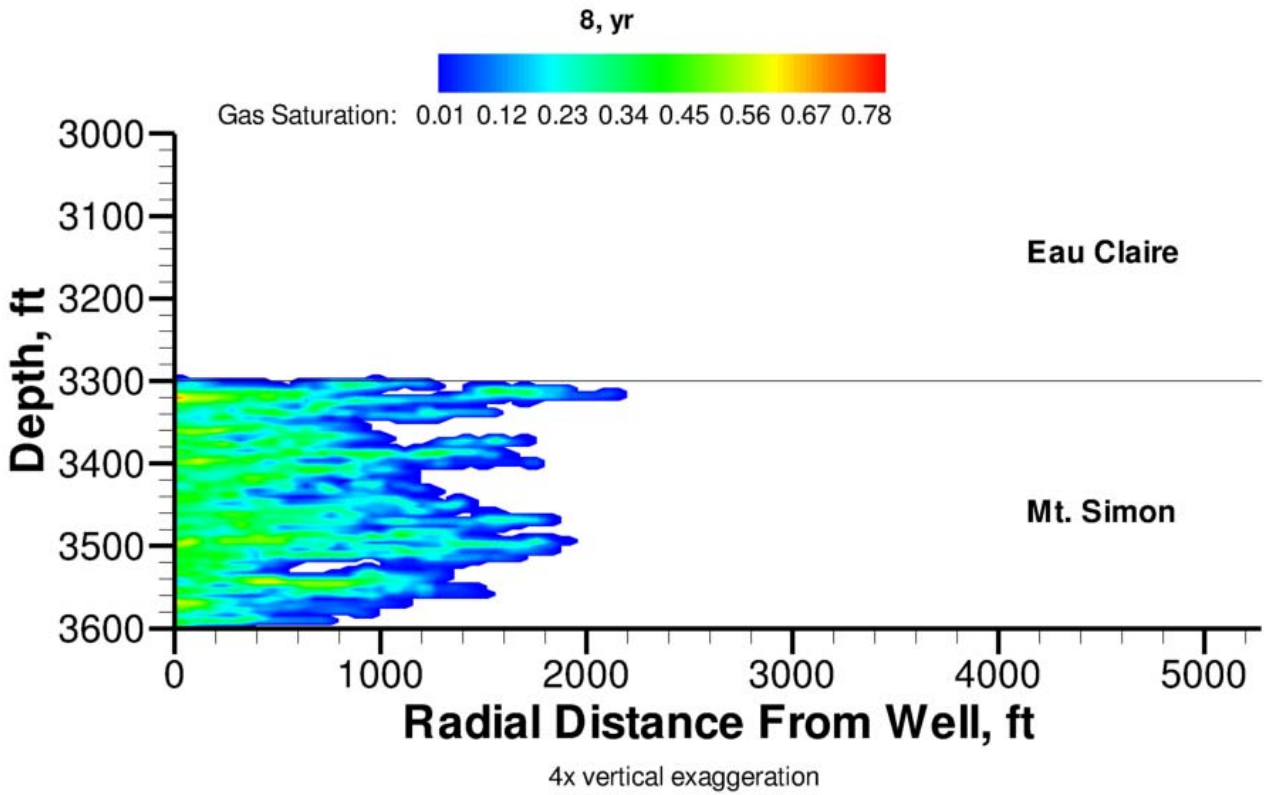

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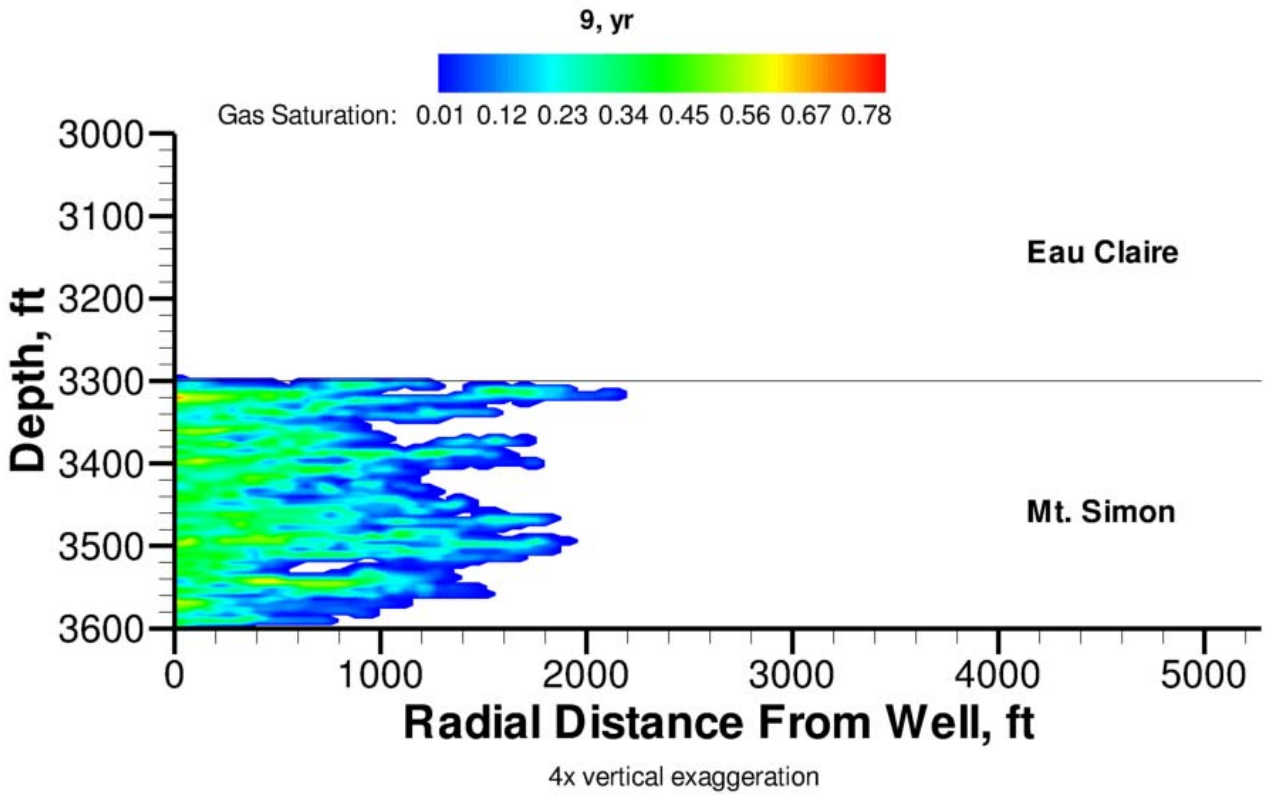

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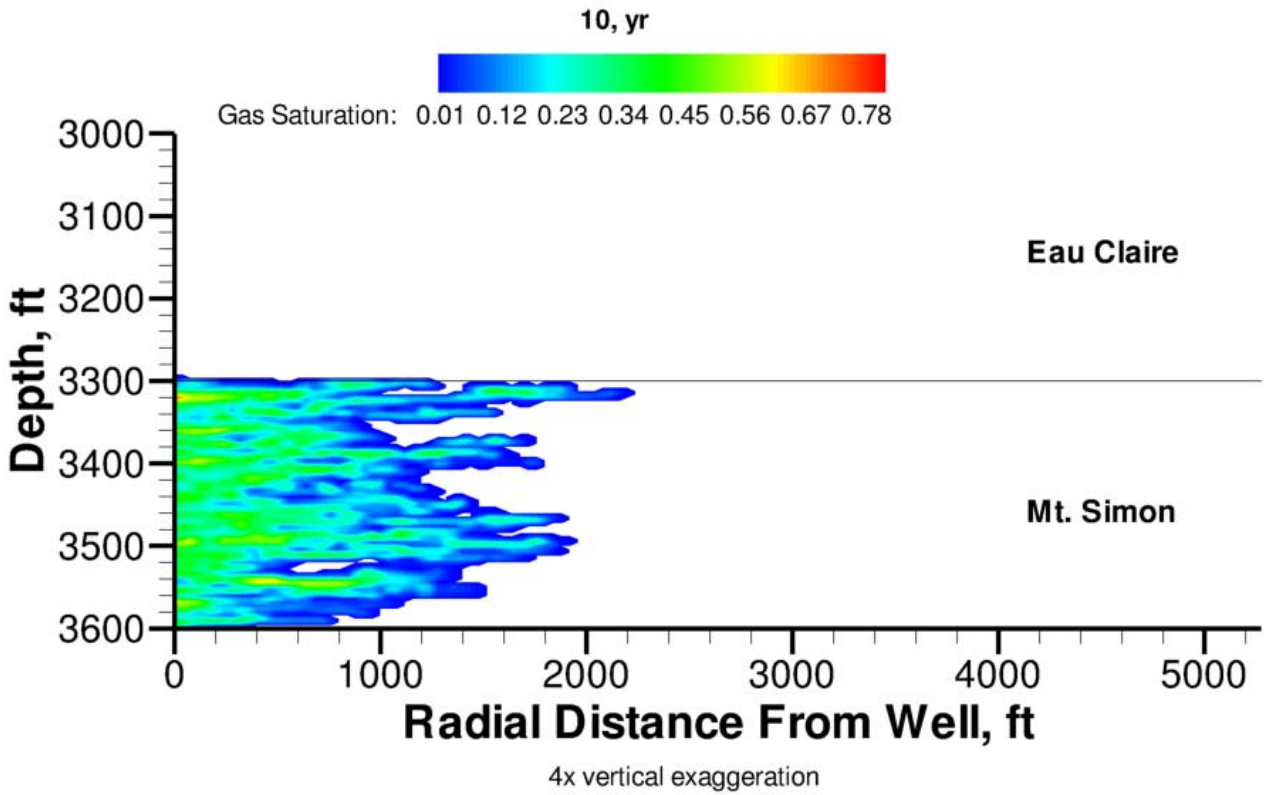
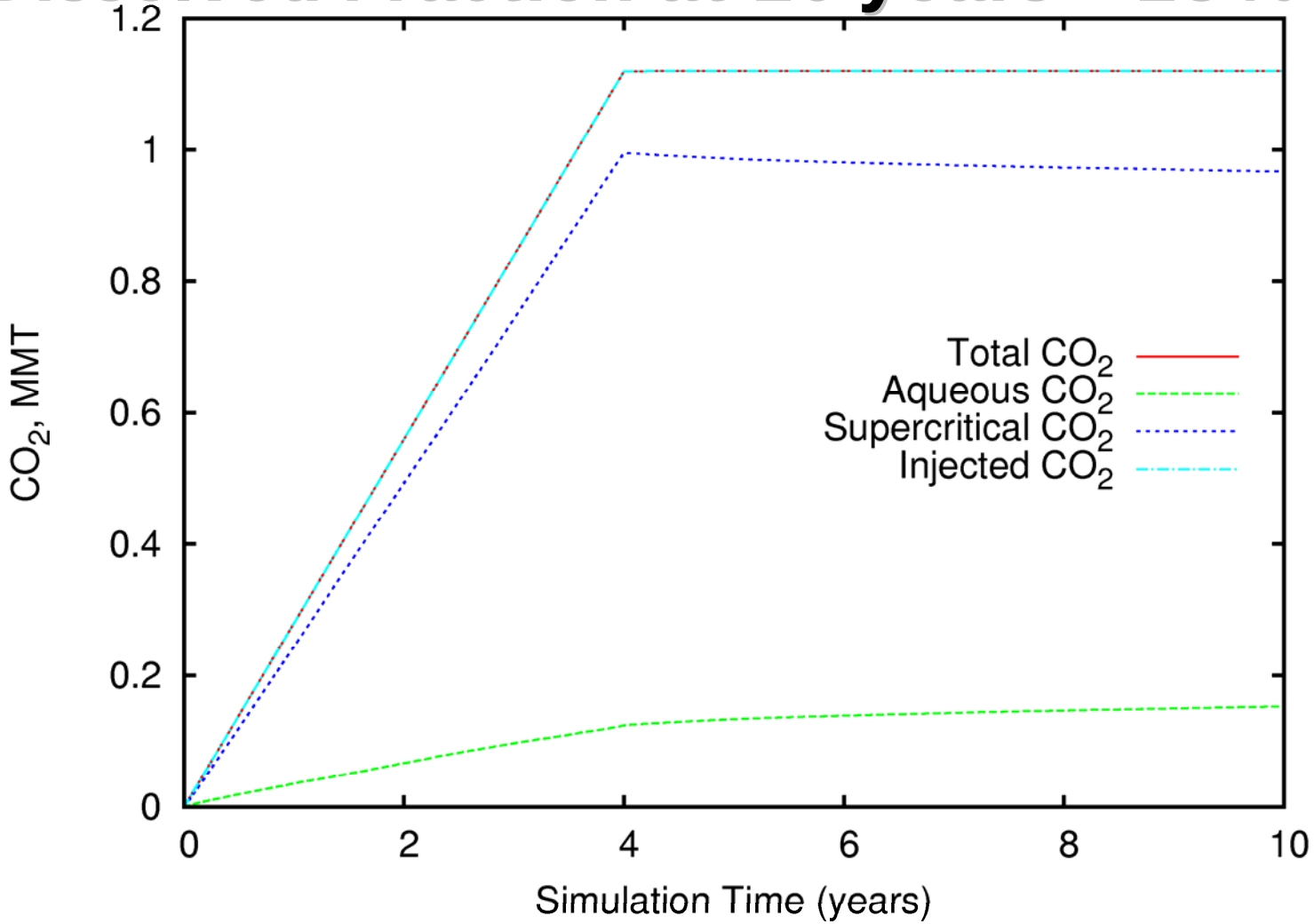
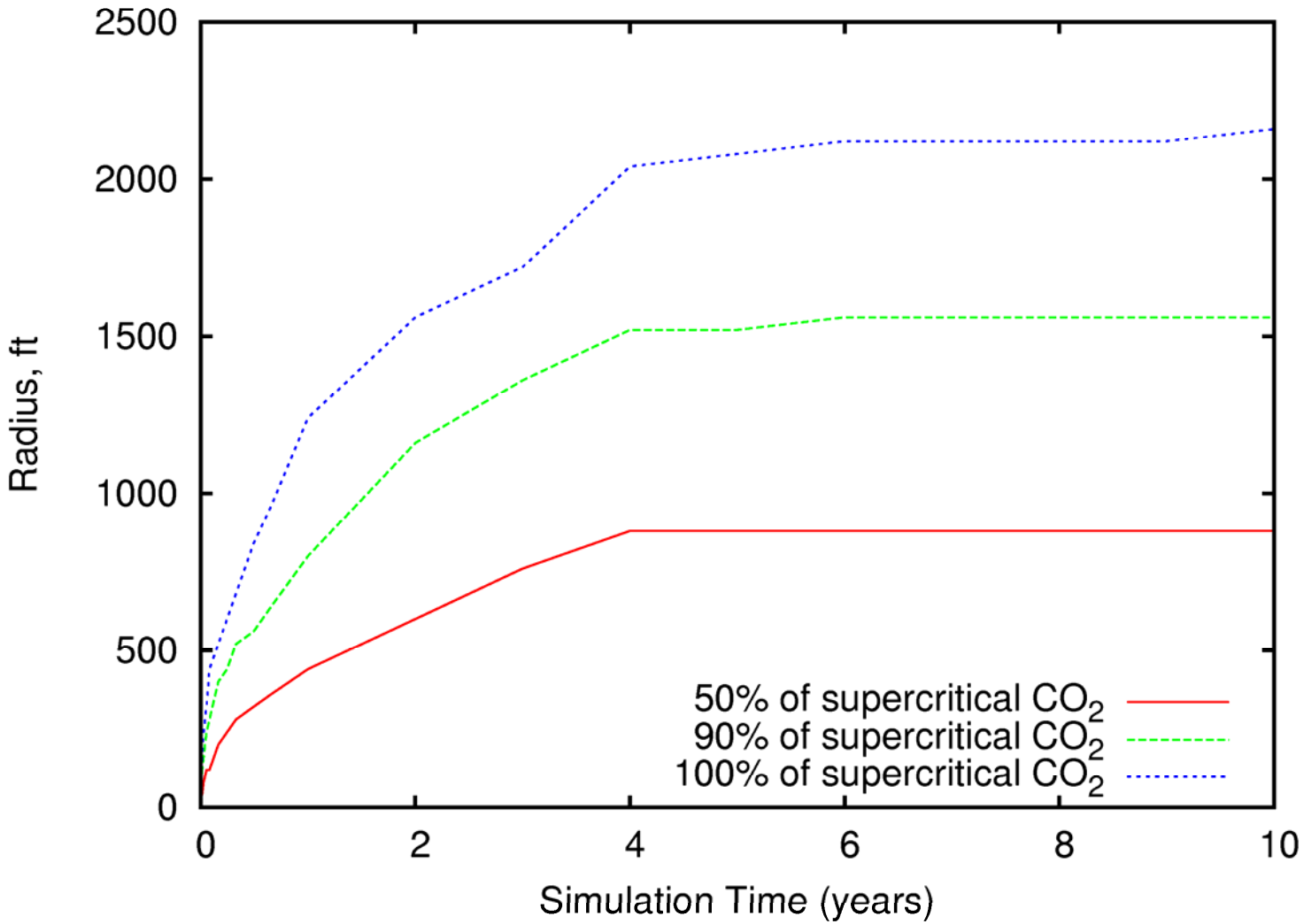


Preliminary Reservoir Simulations – Dissolved Fraction at 10 years ~13%

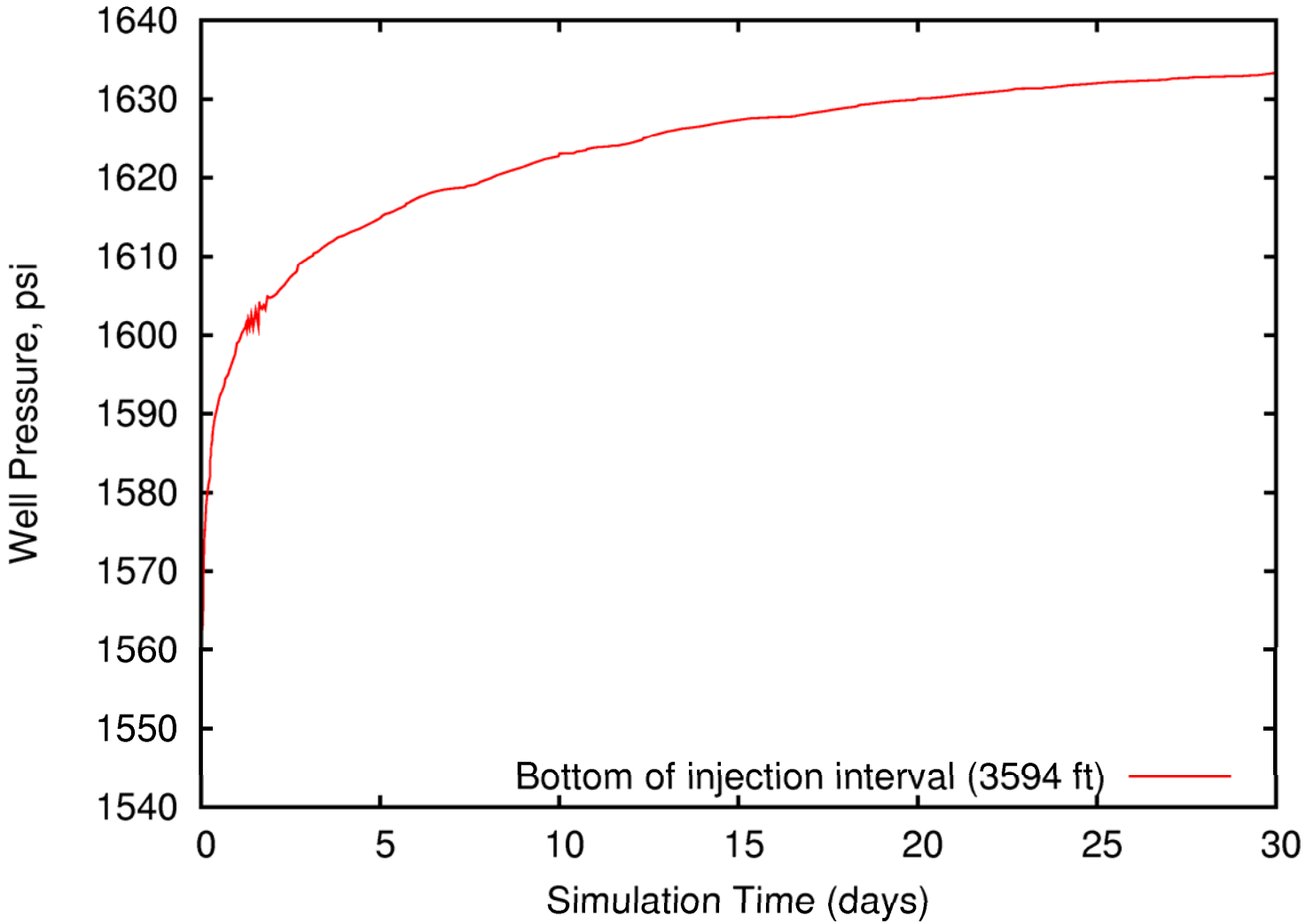


Preliminary Reservoir Simulations – CO_2 Spreading Radii



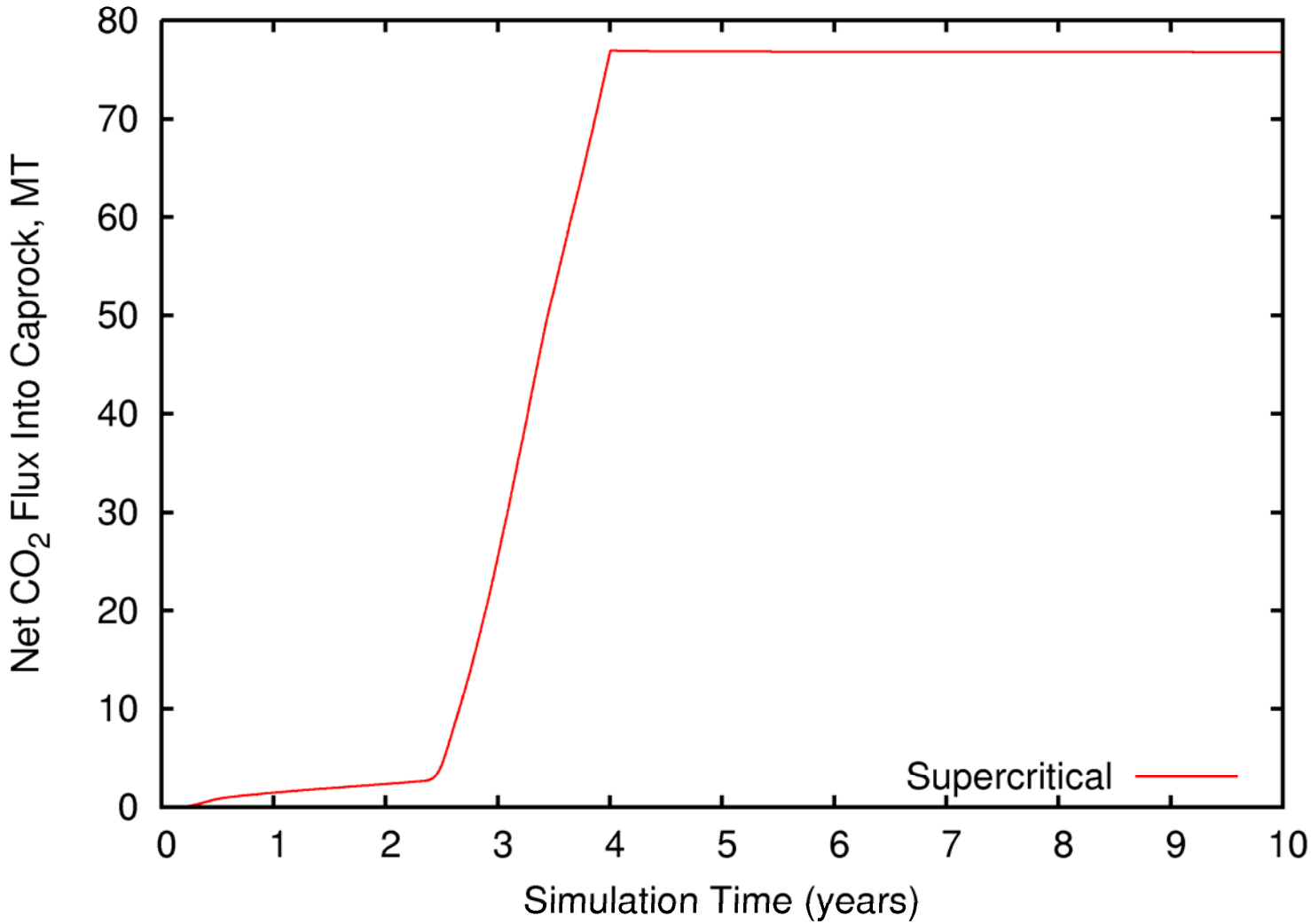
Preliminary Reservoir Simulations –

Pressure Buildup at the Base of Injection Zone << likely Fracture Pressure



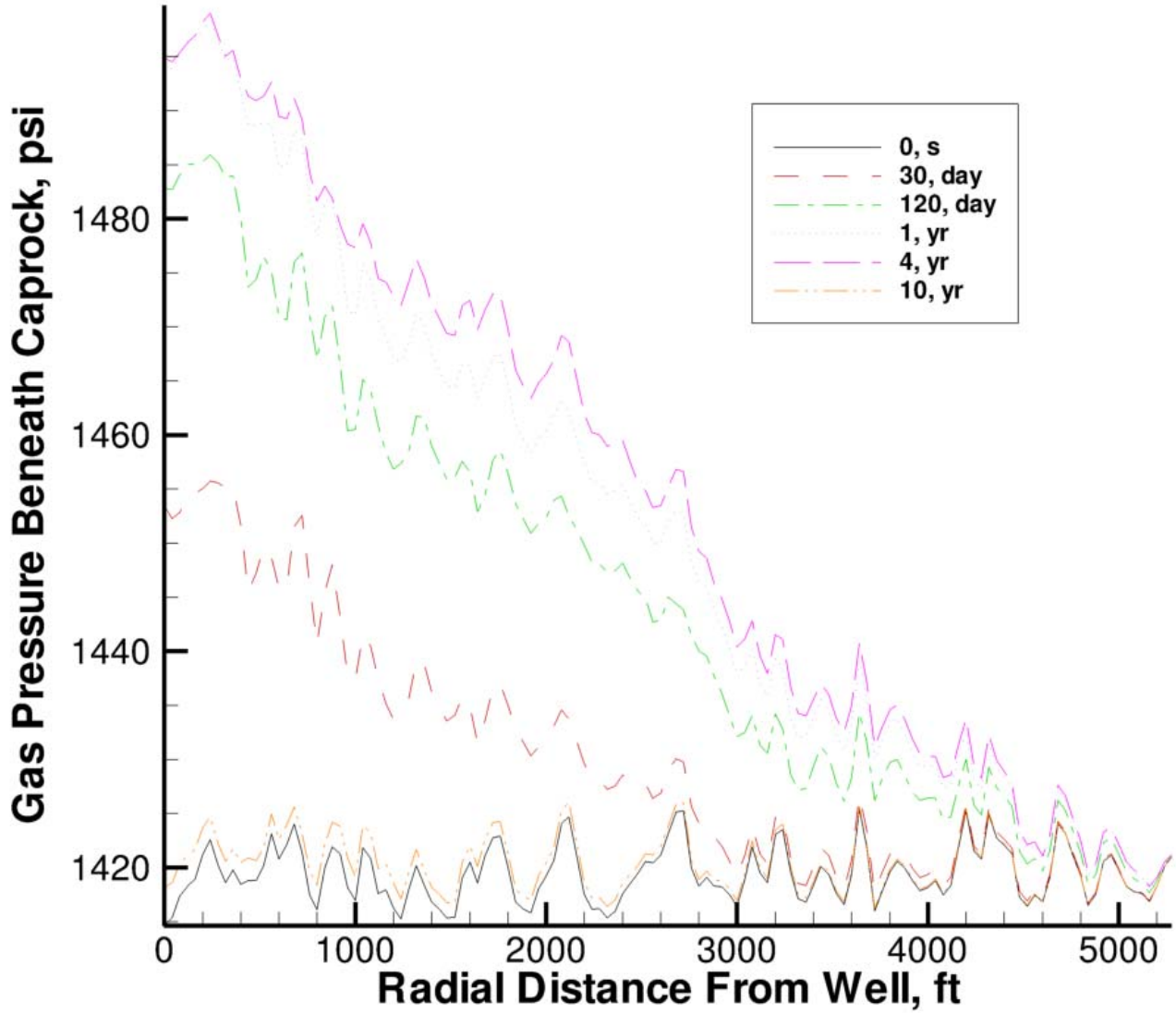
Preliminary Reservoir Simulations –

Diffusive Flux into Lowest Caprock (<100 tonnes, <0.007%)

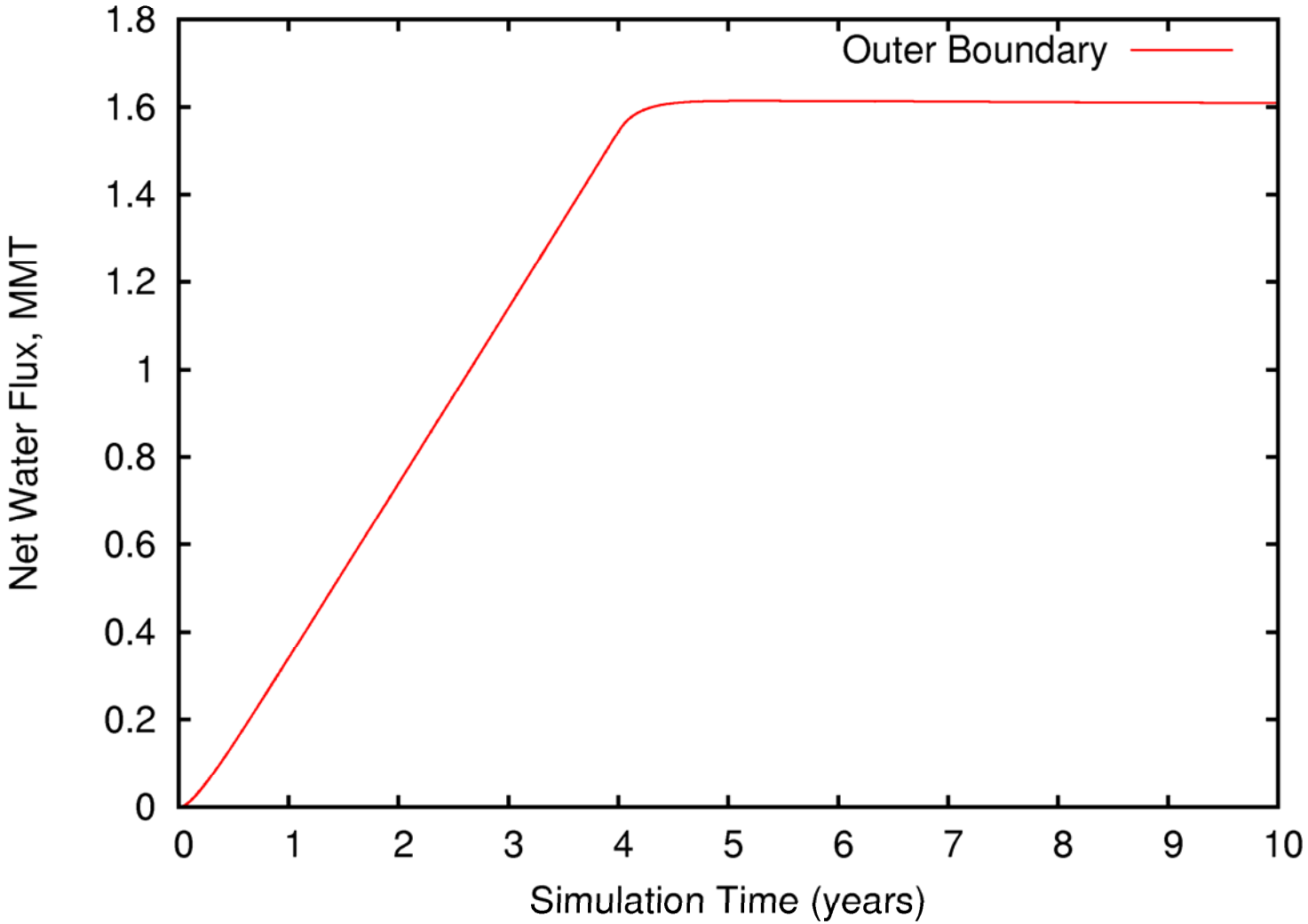


Preliminary Reservoir Simulations –

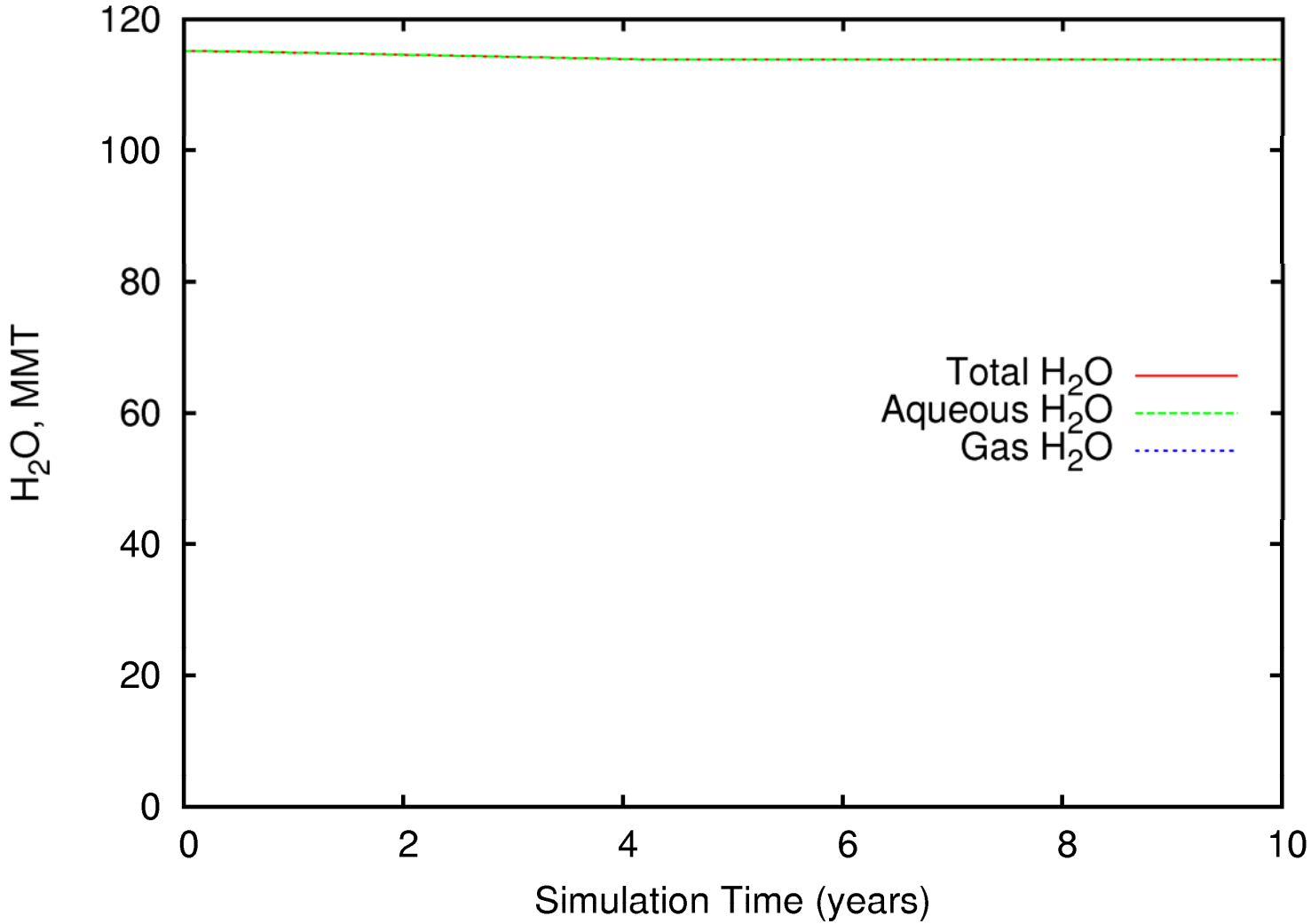
Pressure beneath Caprock Much Lower than Likely Fracture Pressure (>2100 psi at .65 psi/ft)



Preliminary Reservoir Simulations – Water Displaced at Model Boundary



Preliminary Reservoir Simulations –
Amount of Brine Displaced is a small Fraction of System Total



Risk Screening for the MRCSP Phase III TAME Site

- Preliminary risk screening completed for the MRCSP Phase III TAME site.
- Risk screening consisted of 2 main items:
  - Features, Events, and Processes (FEP) performance and safety screening to identify possible risk items.
  - Risk pathway analysis to identify leakage pathways and other risk mechanisms to receptors in the area.
- Conclusions
  - Few FEP items appear to significantly affect CO_2 storage for project.
  - No significant risk pathways are evident in the storage area. Some risk pathways need to be better defined through site characterization.
  - Not enough information is available to do a quantitative risk evaluation at this time
  - Due diligence necessary to characterize site, operate injection system and monitor injection.

Preliminary FEP Screening

- Example of Preliminary screening of Subsurface FEP Items for Western Ohio

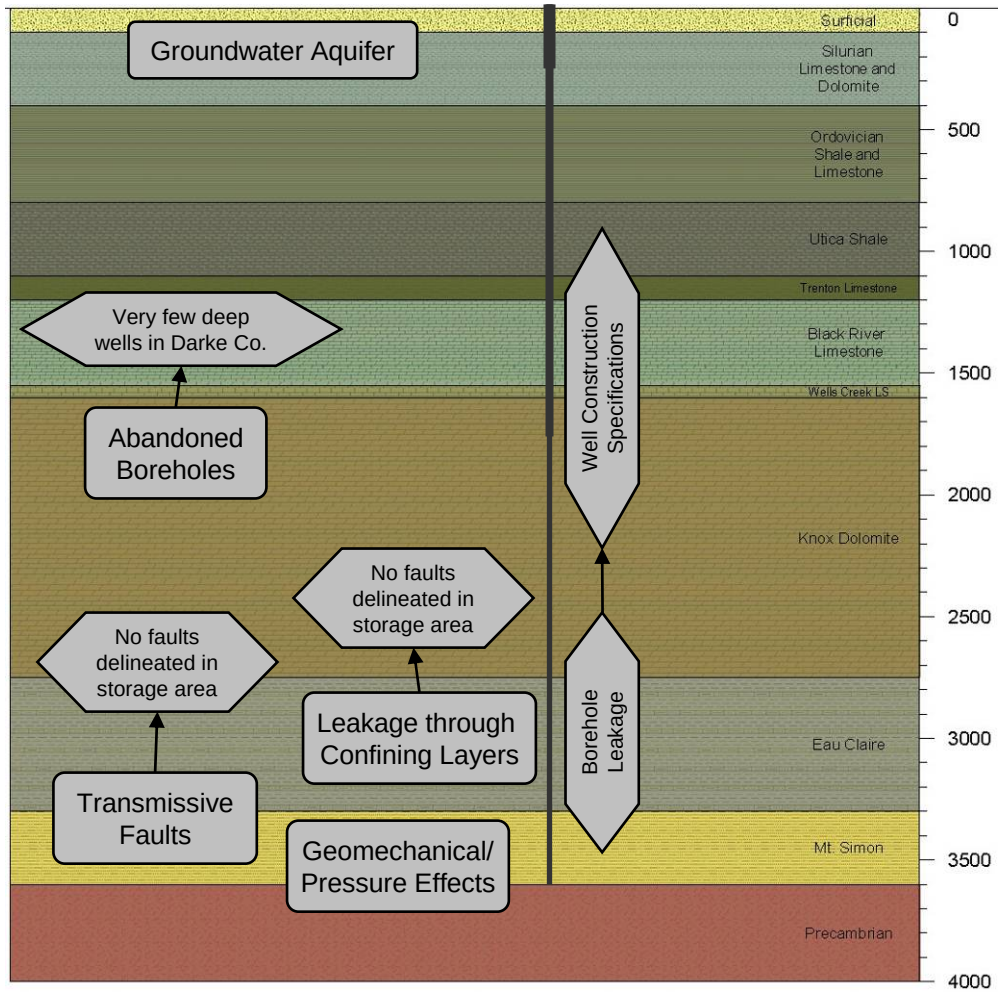
Description
CO2 Interactions
Effects of Pressurisation of reservoir on caprock
Effects of Pressurization on reservoir fluids
Interaction with Hydrocarbons
Displacement of saline formation fluids
Mechanical Processes and conditions
Induced seismicity
Subsidence or uplift
Thermal effects on injection point
Water Chemistry
Interaction of CO2 with chemical barriers
Sorption and Desorption of CO2
Heavy metal release
Mineral phase
Gas Chemistry
Gas Stripping
Gas Hydrates
Biogeochemistry
Microbial Processes
Biomass Uptake of CO2
CO2 Transport
Advection of free CO2
Buoyancy-driven flow
Displacement of formation fluids
Dissolution in formation fluids
Water mediated transport
CO2 release processes
Co-migration of other gases

Explanation
Not applicable
Improbable due to site conditions
Item that needs to be addressed through site characterization
Item requiring more testing at site and/or system monitoring
Item likely to affect system safety or performance

Description
Geology
Geographical Location
Natural Resources
Reservoir Type
Reservoir geometry
Reservoir exploitation
Cap rock or sealing formation
Additional Seals
Lithology
Unconformities
Heterogeneities
Faults and Fractures
Undetected features
Vertical Geothermal Gradient
Formation Pressure
Stress and Mechanical Properties
Petrophysical Properties
Fluids
Fluid Properties
Hydrogeology
Hydrocarbons
Drilling and Completion
Formation Damage
Well lining and completion
Workover
Monitoring wells
Well Records
Borehole Seals and Abandonments
Closure and Sealing of Boreholes
Seal Failure
Blowouts
Orphan wells
Soil Creep around Boreholes

Risk Pathway Analysis

- Risk pathways analysis for the site is planned



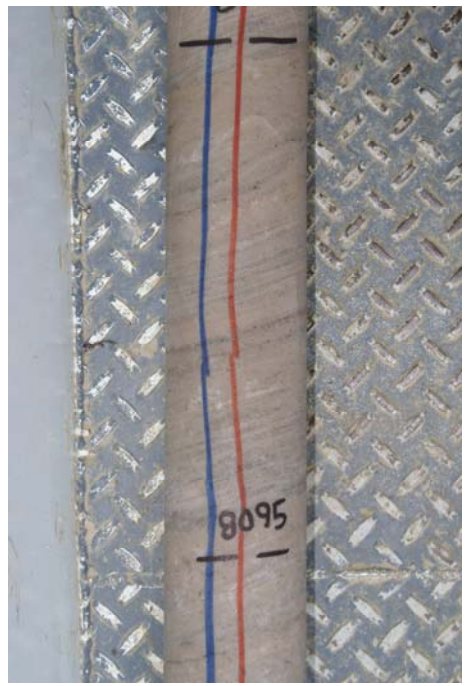
Wastewater Drilling at Edwardsport

- Extensive geologic data is being collected from the wastewater well being drilled as part of the IGCC construction. MRCSP is participating as part of regional characterization of the area.

Site Characterization

Preliminary Geologic Prognosis (before Drilling – subject to changes after Drilling)

Parameter	Description
Geologic Setting	Illinois Basin
Sed. Total Thickness	8,600
Primary Target	Mt. Simon
Lithology	Sandstone
Target Depth Interval (ft)	7,500-8,600
Total Thickness (ft)	1,100
Avg. Porosity	0.1
Avg. Perm. (mD)	10-200
Formation Pressure (psi)	~3,525
Formation Temp. (°F)	130
Secondary Target	Knox Carbonates



Photograph of rock core (Mt. Simon, 8095 ft) collected from wastewater w

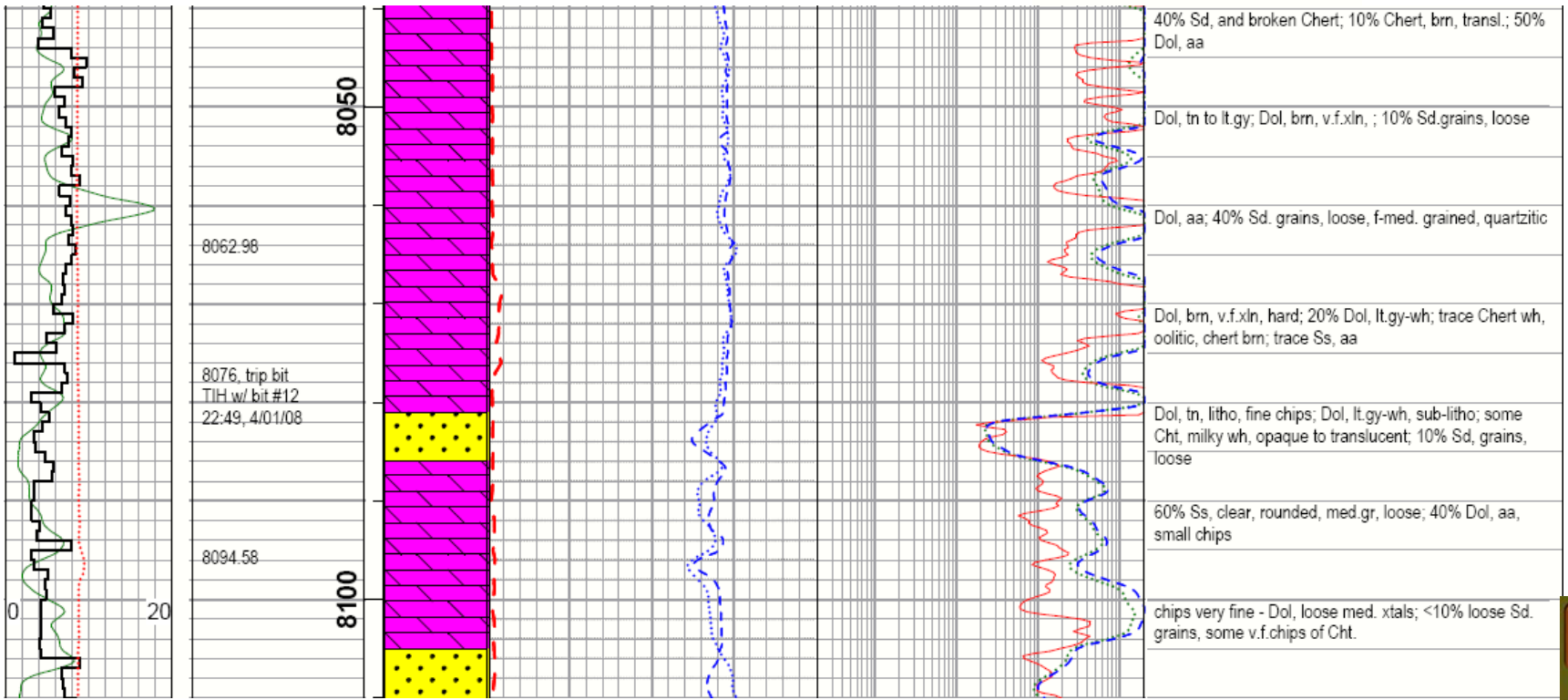
Data from wastewater well drilling is significantly improving our knowledge of geology in the basin

Site Characterization

- Detailed characterization through mud logs, extensive wireline, coring, drill-stem testing, and brine analysis.

Edwardsport Site Characterization

- Example of wireline logging snapshot the Cambrian section that will be of interest for CO_2 storage and containment potential



Brine water chemistry / fluid sampling from Drill Stem Tests

- Sample depths range from ~4,300 – 8,800 ft

Sample Event	Date	Formation	Sampling Interval (ft)	No of Samples (including replicates)	Sample Container
1	6/12/2008	St Peter	4,346 – 4,423	4	50 ml Falcon Tubes
2	6/14/2008	Knox (Everton)	4,418 – 4,453	4	50 ml Falcon Tubes
3	7/25/2008	Oneote Dolomite	5,238 – 5,290	3	50 ml Falcon Tubes
4	7/29/2008	Potosi Dolomite	5,568 – 5,675	4	50 ml Falcon Tubes
5	9/2/2008	Mt. Simon	8,267 – 8,317	9	250 ml Plastic Bottles
6	9/30/2008	Mt. Simon	8,668 – 8,852	18	250 ml Plastic Bottles

- Concentrations of common brine quality parameters, major cations and major anions, and certain metals found in aluminosilicates (Si, Al, Fe, and Mn)
- Limited number of stable isotope measurements

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Thank You

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