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Project OASIS (DE-FE0032267)

Task 4.0 Deliverable – Geologic Analysis Report

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1. INTRODUCTION

Project OASIS (Optimizing Alabama's CO_2 Storage in Shelby County) is a geologic and reservoir characterization study designed to evaluate deep saline formations for potential long-term carbon dioxide (CO_2) storage in central Alabama near the National Carbon Capture Center (NCCC) and Alabama Power's Plant Gaston. The project centers on the Cambro-Ordovician Knox Group and underlying strata such as the Conasauga and Rome Formations, which were investigated through the drilling of two stratigraphic test wells to obtain electronic well logs, core, and sidewall core plugs. These data provide direct measurements of porosity, permeability, and lithologic variability critical for reservoir characterization. Complementing the well program, a limited 2D seismic survey was acquired to help select the site for Westover #2, and a more regional Seismic Exchange (SEI) seismic survey was licensed and interpreted to define structural and stratigraphic frameworks in a new Static Earth Model (SEM), map reservoir continuity, and identify potential sealing intervals. Integrated with geologic and reservoir modeling, these datasets form the basis for evaluating storage capacity, injectivity, and containment.

2. WESTOVER #2 SITE SELECTION

After the completion of the Westover #1 stratigraphic test in early 2022, which was completed as part of SECARB-USA (DE-FE0031830), the project team determined that seismic data was necessary to delineate the subsurface structures at Project OASIS before selecting a follow-up location for the Westover #2 well. The initial stratigraphic test wellbore (Westover #1) was unable to reach the target storage formations due to adverse drilling conditions encountered in a tectonically thickened section of geomechanically weak shales of referred to as MUSHWAD (malleable unctuous shales within a ductile duplex). **Figure 1** shows the location of Project OASIS in proximity to regional lime and cement plants, pulp and paper plants, and Alabama Power's Plant Gaston. Following this first drilling attempt, seventeen line-miles of 2D seismic data were acquired by Exoduas, Inc. as part of SECARB-USA (DE-FE0031830) to improve structural interpretation and to identify a more favorable location with reduced drilling risk.

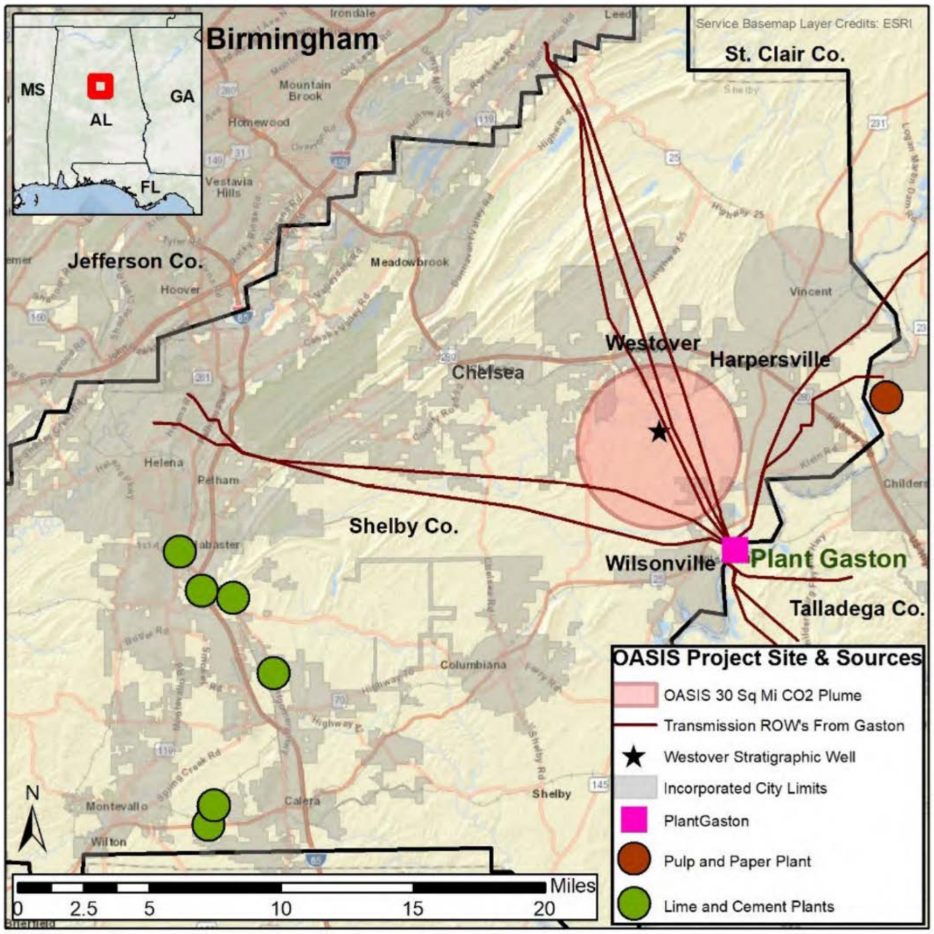

Figure 1. Location of Project OASIS and regional emitters.

The Westover #2 Strat Test was originally planned to be drilled on the same pad as the Westover #1, which would have eliminated the impact of constructing a new well pad. However, the thickness of the MUSHWAD section was unknown, and there was uncertainty regarding the depth to the target formations. As a result, the decision was made to conduct a 2D seismic survey across the Westervelt property to identify a new well site.

In November 2022, a multi-2D seismic reflection survey was acquired by Exoduas, Inc. across the areas of interest. Three lines of receivers, totaling 17 line-miles, were laid out along roadways with 55-foot receiver spacing and 110-foot source spacing. Four vibroseis trucks, sweeping 2–100 Hz and leaving all receivers active for all shots, produced a trace length of 5,000 ms. The post-stack depth migrated lines from the survey imaged to the crystalline basement at depths greater than 15,000 feet. Interpretation of the newly acquired 2D seismic data provided an improved understanding of the geologic structures present within the field area, which led to the selection of a new, optimized drilling location with reduced geologic risk (**Figure 2**).

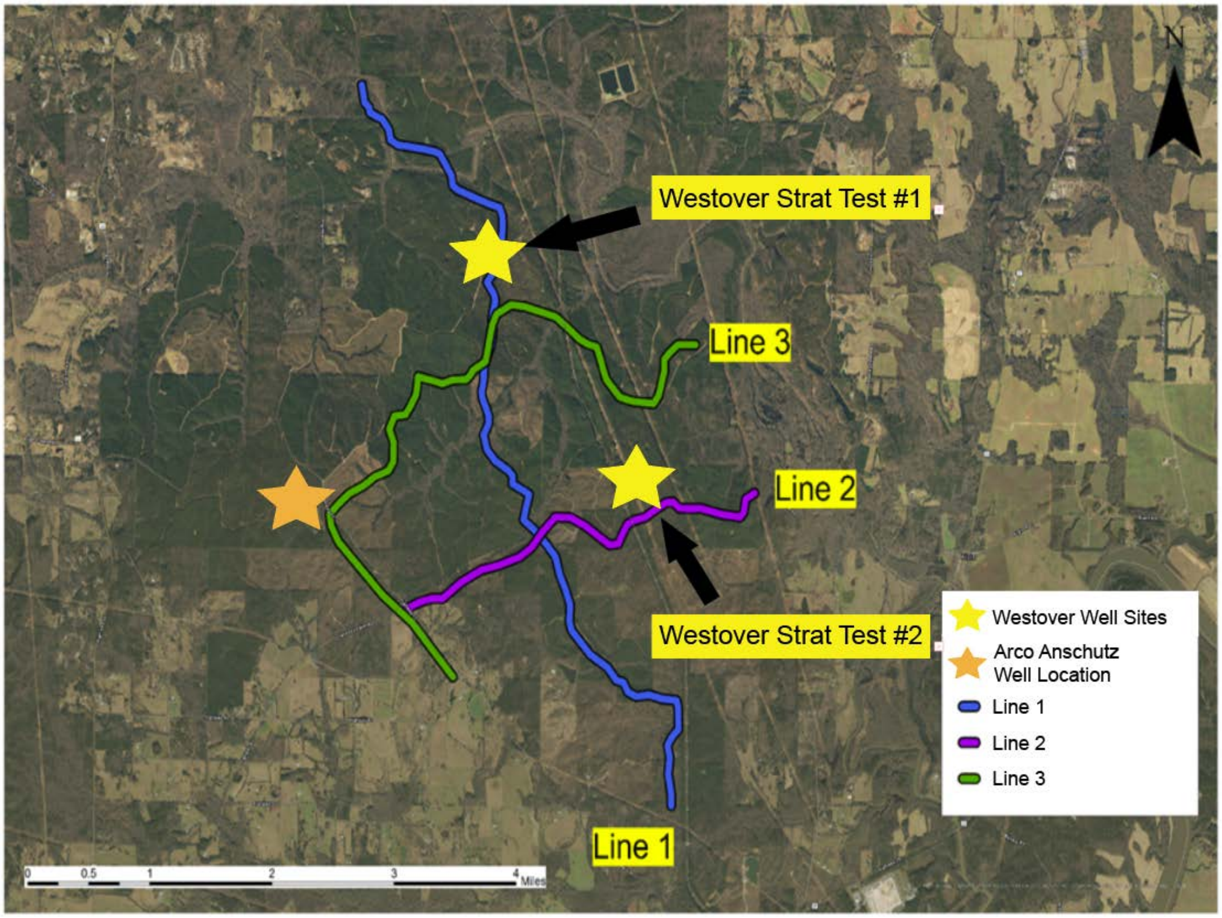

Figure 2. Exoduas, Inc. 2D seismic map with well locations noted.

As shown on the seismic panels in **Figures 3 and 4**, Westover #2 was relocated to a site with an interpreted thinner MUSHWAD section, which resulted in drilling through a reduced thickness of geomechanically weak shales. This in turn decreased the time required to reach the target formations and lowered the risk of drilling complications. Seismic interpretation also suggested that portions of the area contained a repeat section of the target formations due to the presence of a thrust fault ramp. This repeat section provided a second opportunity to measure and sample the target reservoirs.

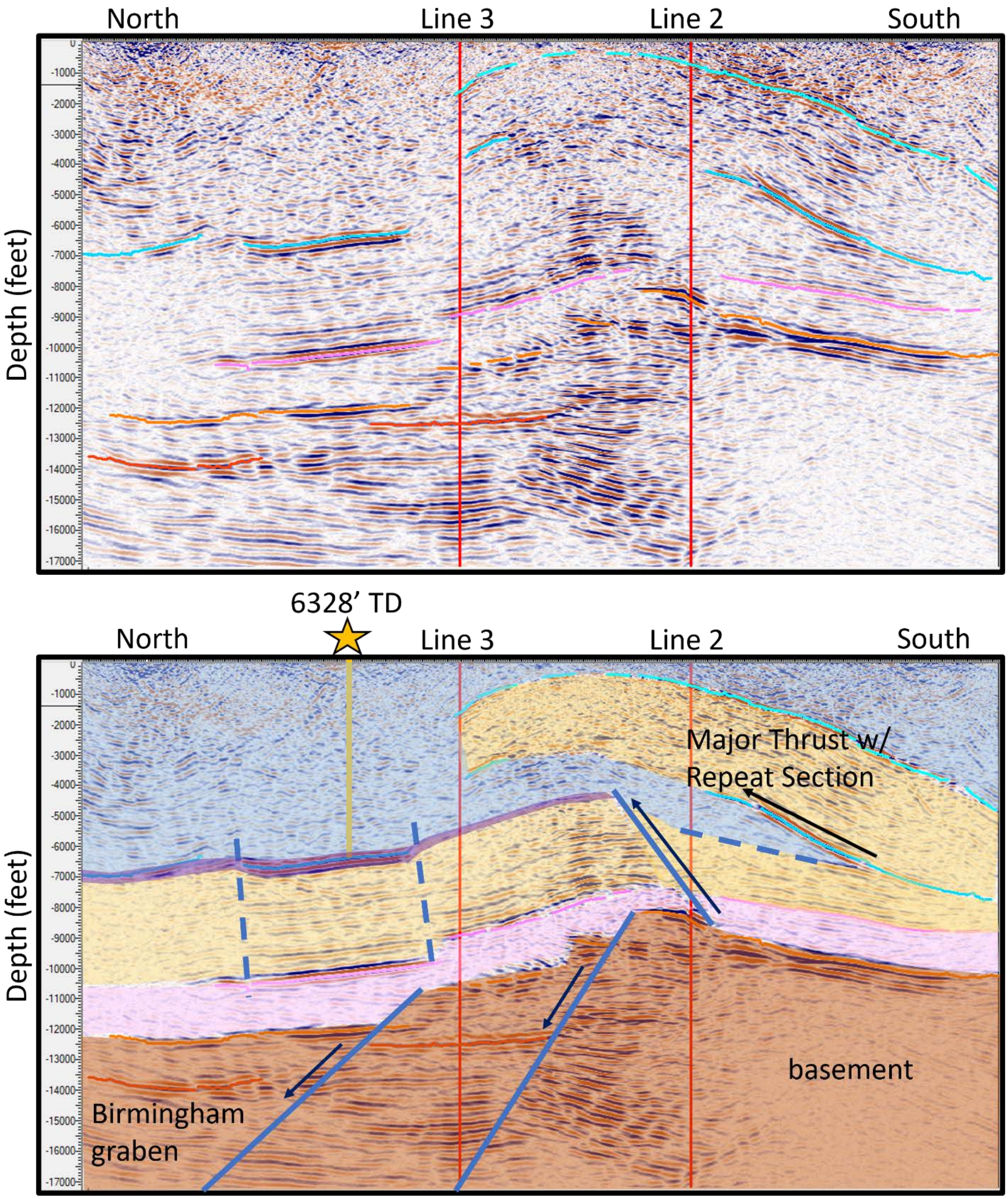

Figure 3. Line 1 runs North-South through the fault ramp structure. The top figure shows the interpreted seismic while the bottom shows the initial interpretation of delineated formations.

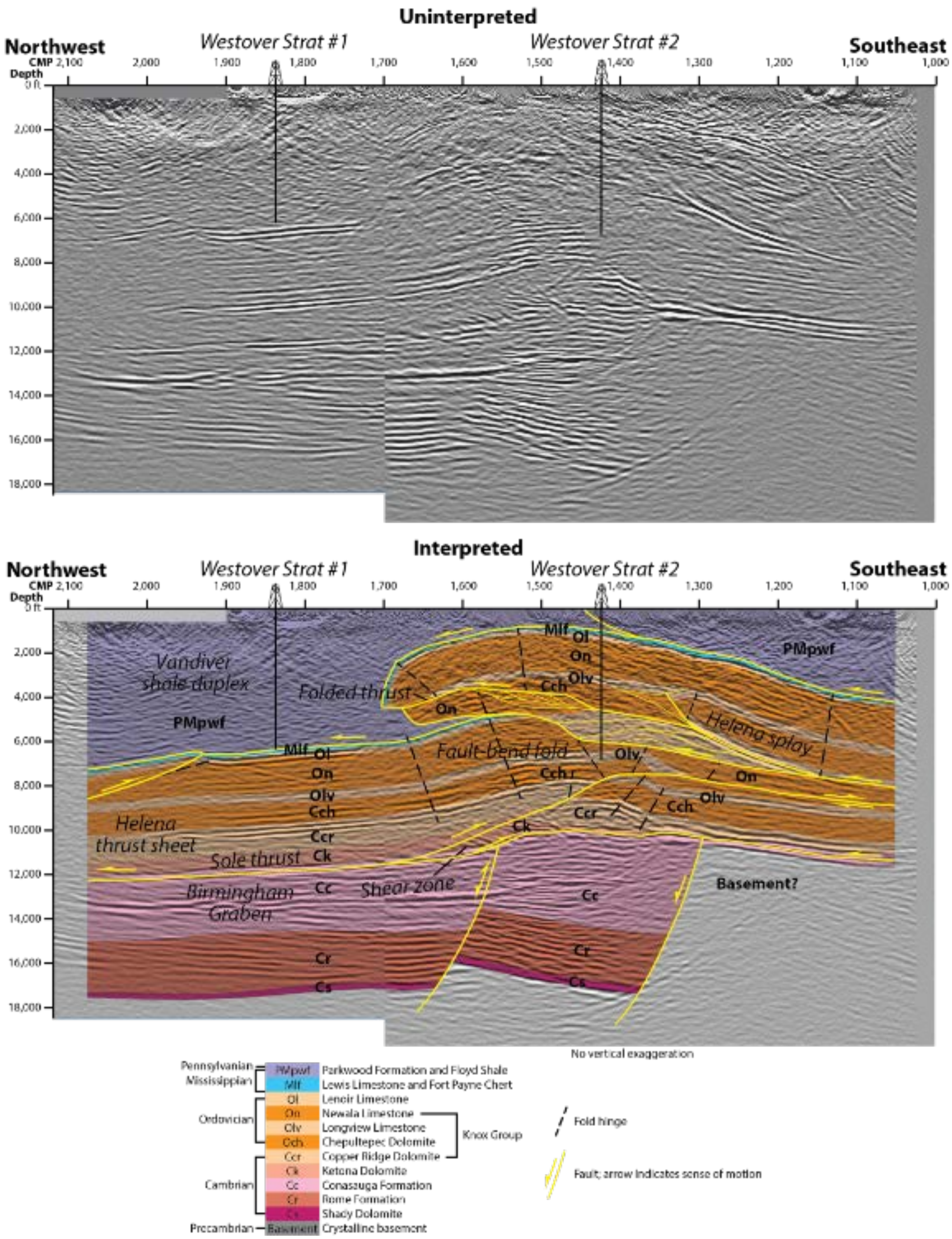

Figure 4. A stratigraphic column of the geologic units at Project OASIS along with a structural interpretation of the Line 1 panel by Dr. Jack Pashin shows the chosen location of Westover #2.

3. WESTOVER #2 LOGS AND CORE

The Westover Strat Test #2 **(Figure 5)** was spud on October 10, 2023, using the WT Rotary Drilling Rig #18 and drilled to a final total depth of 6,725 ft on November 2, 2023.

Well Type:	Stratigraphic Test
Well Location:	
Lease Name:	Westover Strat Test #2
Well Name:	#2
API Number:	N/A
County, State:	Shelby County, Alabama
Well Location: (Geographic survey)	Latitude: 33° 17' 35.377" Longitude: -86° 29' 32.579"
Well Location: (Description)	Shelby County, Alabama Section 13 Township 20 South, Range 1 East Section 13 Township 20 South, Range 1 East
Well Data	
Spud Date:	10/10/2023
Target Formation:	Cambrian-Ordovician Storage Reservoir
Total Well Depth:	6,725 feet below KB
Elevation (MSL):	Ground Level (GL) 506 feet Kelly Bushing (KB) 527 feet

Figure 5. Westover Strat Test #2 well information.

Surface Section

The surface section was drilled using two 14-3/4-inch drill bits (1 PDC & 1 Tri-cone) to a total depth of 1,005 ft reached on October 13, 2023. A water-based mud was used as the drilling fluid, and the average rate of penetration (ROP) for the surface section was 19 ft/hr.

Once total depth was reached, a triple-combination logging suite (Gamma Ray, Neutron-Density, Resistivity) was employed in the open-hole from the surface casing point up to the conductor casing shoe. Following the open-hole logging suite, a 10-3/4-inch surface casing was run to a total depth of 1,005 ft and cemented in place. A cement bond log (CBL) was run after sufficient cement cure time which indicated cement coverage from total depth up to the surface.

Open-Hole Section

The open-hole section was drilled using seven 8-3/4-inch drill bits (all PDC) to a total depth of 6,725 ft reached on November 2, 2023. A water-based mud was used as the drilling fluid, and the average ROP for the open-hole section was 18.02 ft/hr.

Prior to total depth, a whole core point at 3,200 ft was selected and a core bit was deployed and attempted to cut 60-120 feet of whole core. Due to rock hardness and jamming, only 19 feet of whole core was collected, of which 17.5 ft were fully recovered. Drilling continued until total depth through hard limestone/dolomite that commonly contained traces of chert and sandstone **(Figure 6)**. Analysis of the whole core was conducted by Core Lab with additional work by graduate students and faculty Auburn University. The results showed very little pore space with most potential spaces filled with calcite cement. There is evidence of fractures, some of which are calcite filled, and some are open.

Figure 6. An example of slab cut core from the Westover #2.

Once total depth was reached, a quadruple-combination logging suite (Gamma Ray, Neutron-Density, Resistivity, Sonic), magnetic resonance, and a micro-imager log (FMI) were deployed from total depth up to the surface casing shoe. The rotary sidewall coring tool was then deployed for 60 planned core points, of which only 49 attempts were made due to rock harness/instability, and a total of 39 sidewall cores were recovered. See **Figure 7** for the final well schematic.

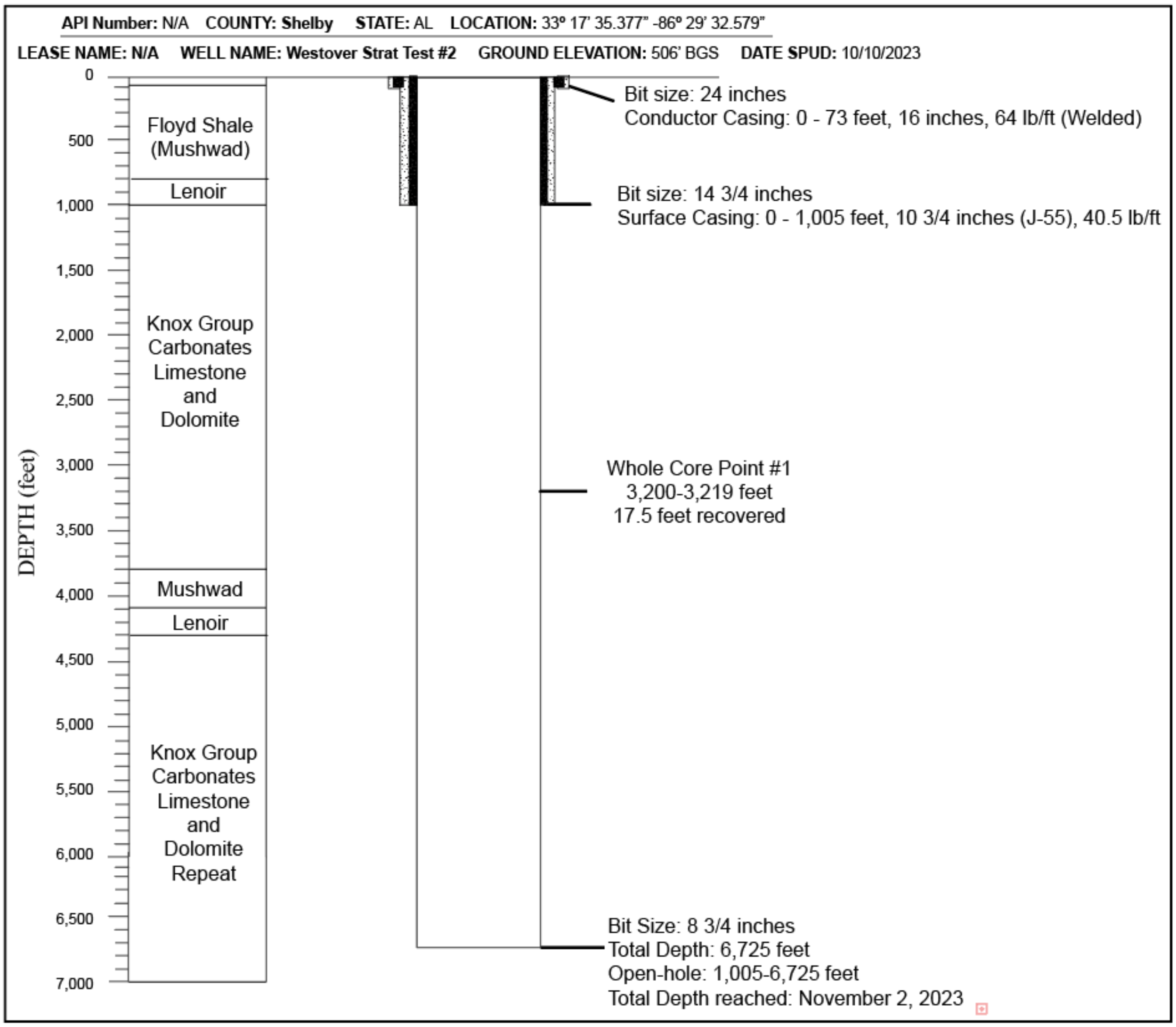

Figure 7. Westover #2 final well bore schematic.

The logs show a stacked sequence of extremely tight carbonates with little preserved porosity. The section is highly fractured although many fractures are sealed with calcite. The areas with higher porosity, which is still less than 3%, tend to be in these fracture zones.

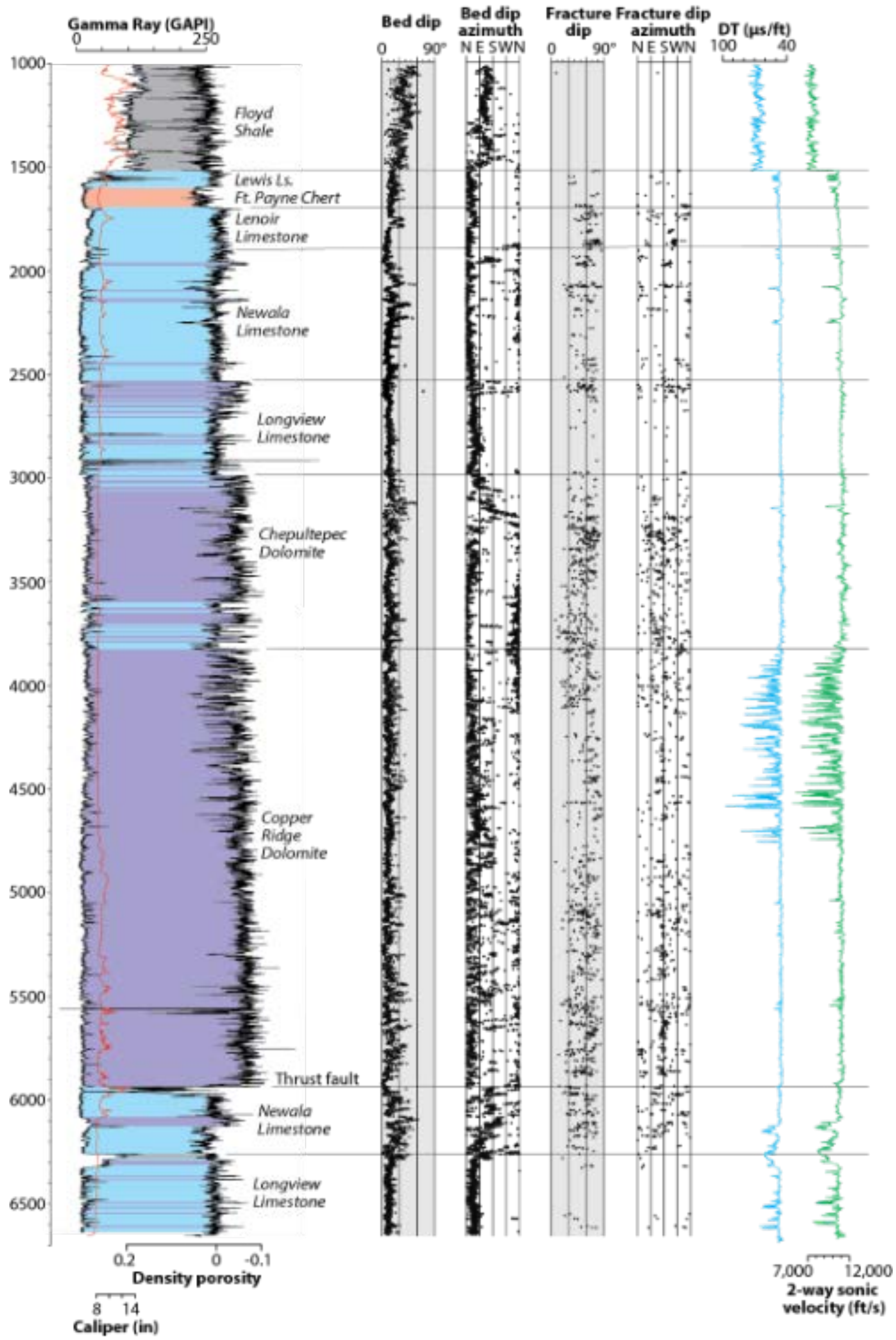

Figure 8. Summary of Westover #2 logging, including the gamma ray, density, sonic, and bedding dip information derived from FMI logs.

After the difficulty attempting to core the whole core section, the project team decided to divert the remaining coring budget to one-inch rotary side wall cores. The earth science team chose a list of sixty desired core points based on the data from the quadruple combination log run. Gamma ray and neutron density logs were used to identify any zones with potential porosity. While the logs showed the carbonates were very tight overall, there were some 10-to-20-foot porous zones throughout the Knox Group. Other points were chosen to test shales, sealing units, and an interval within a calcite fault gouge between the two Knox Group repeat sections. The rotary sidewall core unit also struggled with the hard carbonates. Of the sixty planned cores, thirty-nine were collected. Some planned intervals were skipped due to no penetration while the last eleven shallow points were not collected due to the coring bit wearing out. These core plugs were shipped to Core Lab in Houston, Texas for cleaning and analysis and studied by Auburn University **(Figure 9)**. The whole core was packaged and sent to the Geological Survey of Alabama Core Warehouse in Tuscaloosa, Alabama for storage.

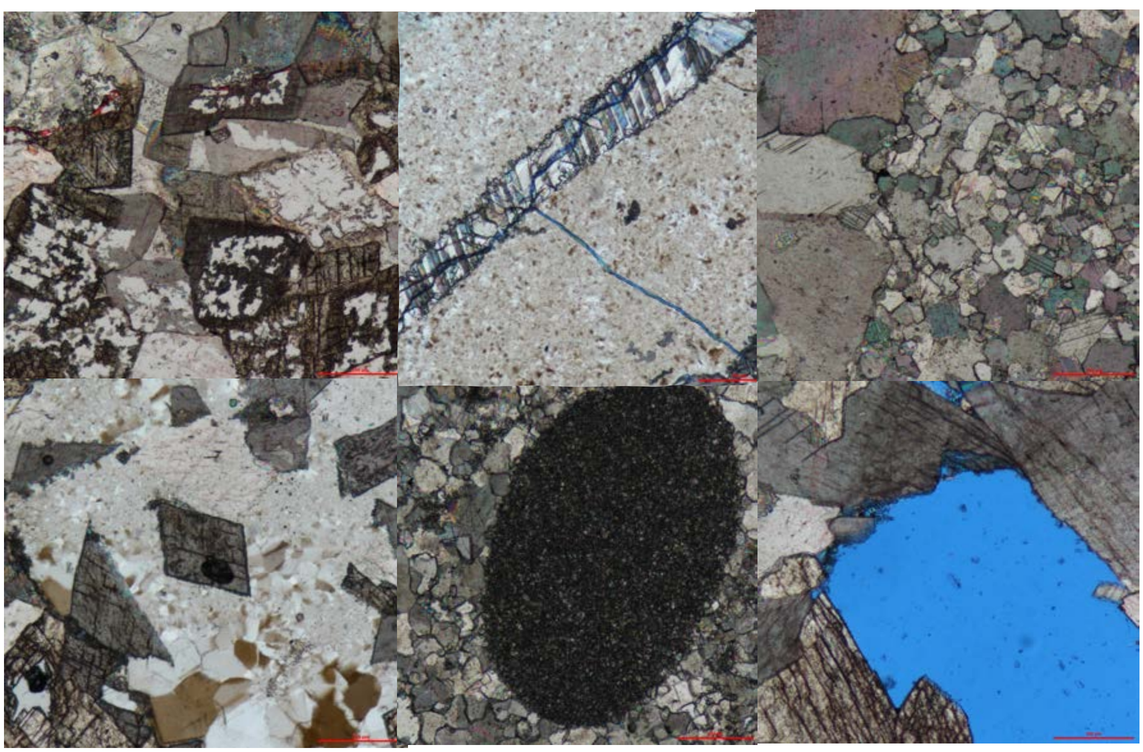

Figure 9. Sidewall core thin sections showing veins and fractures between crystalline dolomite. Blue indicates vuggy porosity.

Formation micro-imager (FMI) logs are particularly valuable in hard carbonate because they provide high-resolution, image-based representations of the borehole wall that allow for direct identification of natural fractures, faults, and bedding features that may not be visible in conventional logs. In these low-porosity, tight carbonates, where matrix properties alone underestimate reservoir potential, FMI logs help distinguish conductive versus resistive fractures, determine fracture orientation and density, and evaluate connectivity. The fractures in the lower Knox are of particular interest because they may increase the storage potential of the otherwise tight dolomite (**Figure 10**).

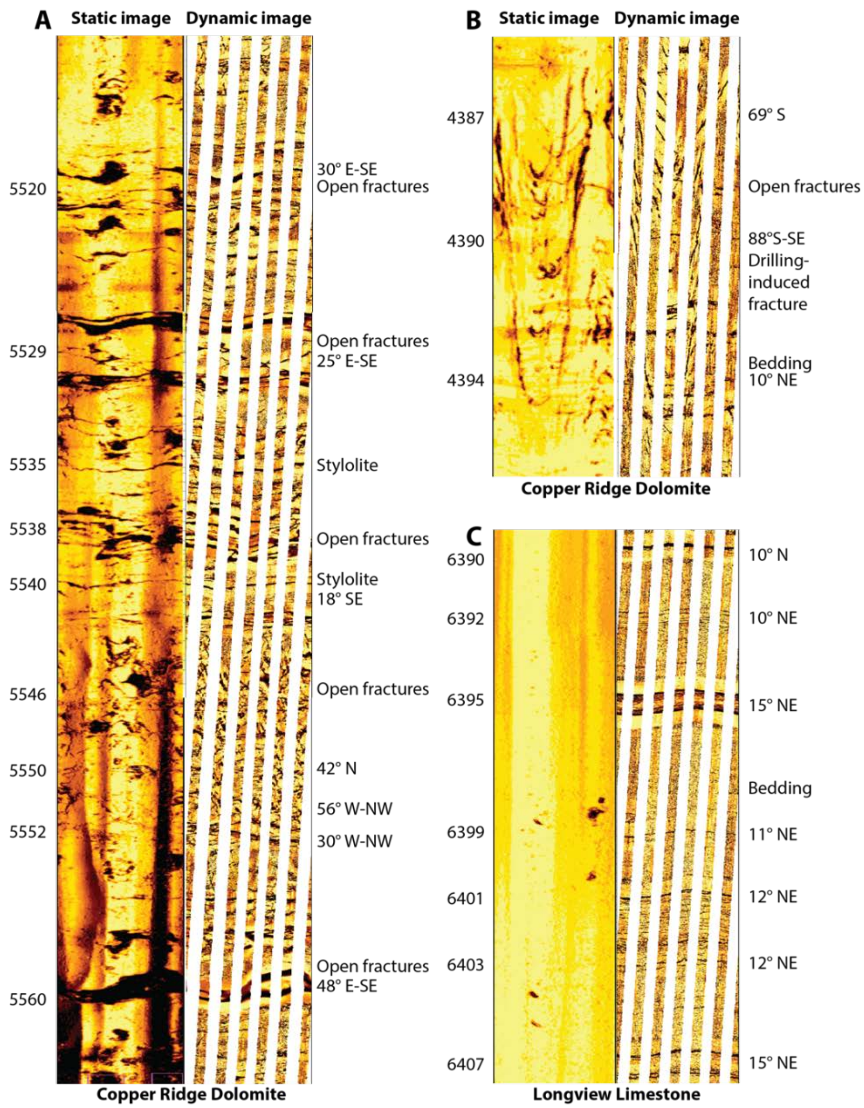

Figure 10. An example of the formation micro-imager log showing bedding and fractures in the Knox Group carbonates.

4. OASIS OFFSET WELLS

The Westover Strat Well #1 drilled through over 6,000 feet of Floyd-Parkwood MUSHWAD without entering the underlying Cambro-Ordovician section. To delineate the subsurface geology, a series of 2-D seismic lines were acquired over the OASIS field area. Based on the seismic interpretations, it is believed that the top of the Ordovician was just below the Westover Strat Well #1 total depth. Westover Strat Well #2 was moved south from the original location to the crest of an interpreted thrust fault ramp associated with the flank of the Birmingham Graben and the Pell City Splay. This allowed the well to penetrate the Cambro-Ordovician section at a much shallower depth of approximately 1,000 feet while avoiding a thickened MUSHWAD section. In addition, due to the repeat section, the Knox could potentially be drilled through twice to observe differences in composition and fracturing. A stratigraphic column of these formations is shown in **Figure 11**.

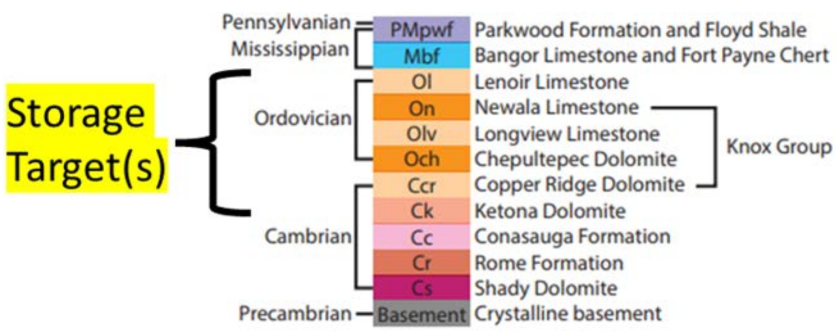

Figure 11. A stratigraphic column of the geologic units encountered in the Westover and Arco Anschutz well bores.

.ARCO-Anschutz 15-11 #1 was drilled in a structural high, avoiding most of the Floyd-Parkwood MUSHWAD. The wellbore entered the Cambro-Ordovician section at 960 ft measured depth. The Wellbore entered the Top of the Newala (Top of the Knox Group) at 1,199 ft and drilled through a repeat sequence of it at 5,196 ft. At 10,484 ft the wellbore entered the Conasauga (a local shale gas target). Below are phylittic shales and iron-stained chert until the wellbore reached basement at 13,977 ft. Upon reaching TD 17,005 ft, logs were run.

The William Smith 9-2 #1, located 21 miles southwest, is a gas exploration well drilled by White-Tail Exploration **(Figure 12)**. During a wider look into the area, it was found to be the closest well to the original area of interest with a depth greater than 3,000 ft. The William Smith spudded on July 15, 2001. It encountered the Floyd-Parkwood MUSHWAD at 1,052 ft measured depth and stayed in it until its TD of 8,720 ft. An initial overview of the well was undertaken because it was thought that perhaps the William Smith 9-2 1 drilled into a dry reservoir. While it appears the Conasauga was the intended target, logs show it was never reached.

Figure 12. Regional well map showing the proximity of the William Smith 9-2 1 and Arco/Anschutz wells to Project OASIS.

5. SEI REGIONAL SEISMIC

In 2022, a total of 17 line-miles of 2D seismic data were acquired to guide the selection of the Westover #2 characterization well location. This targeted acquisition was designed to reduce uncertainty in structural interpretation and to better constrain potential reservoir intervals within the Knox Group. To build a more robust regional static earth model an additional 50 line-miles of vintage seismic data were licensed from the Seismic Exchange in 2025, providing broader regional coverage to refine the thrust fault ramp and area covered by fractures.

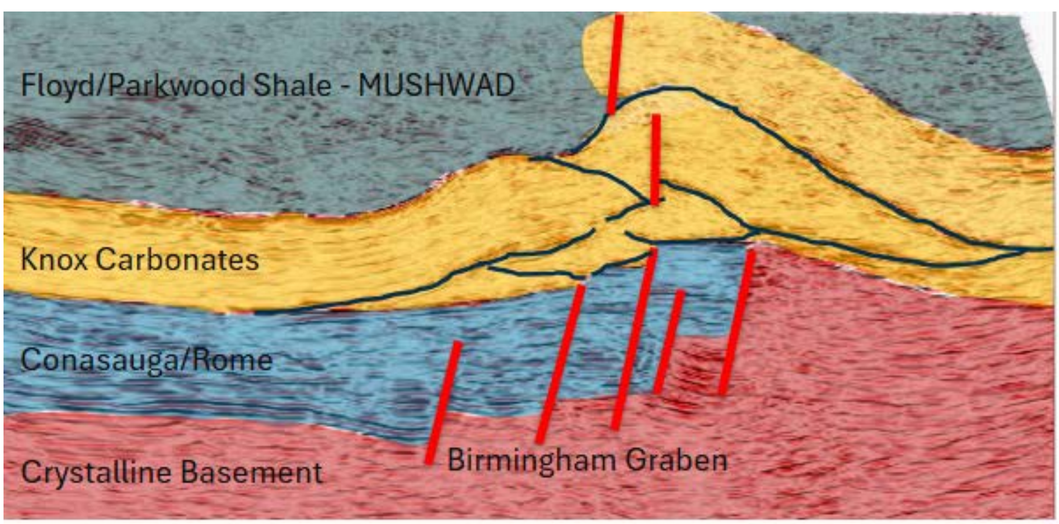

Figure 13. Schematic of the new interpretation of a north-south line (PS-3) from SEI.

The new and vintage datasets were integrated with well logs from Westover #1, Westover #2, and the historic Arco-Anschutz #1 exploratory well. This combination of data allowed for improved delineation of the subsurface and served as the foundation for building a geologic model **(Figure 14)**.

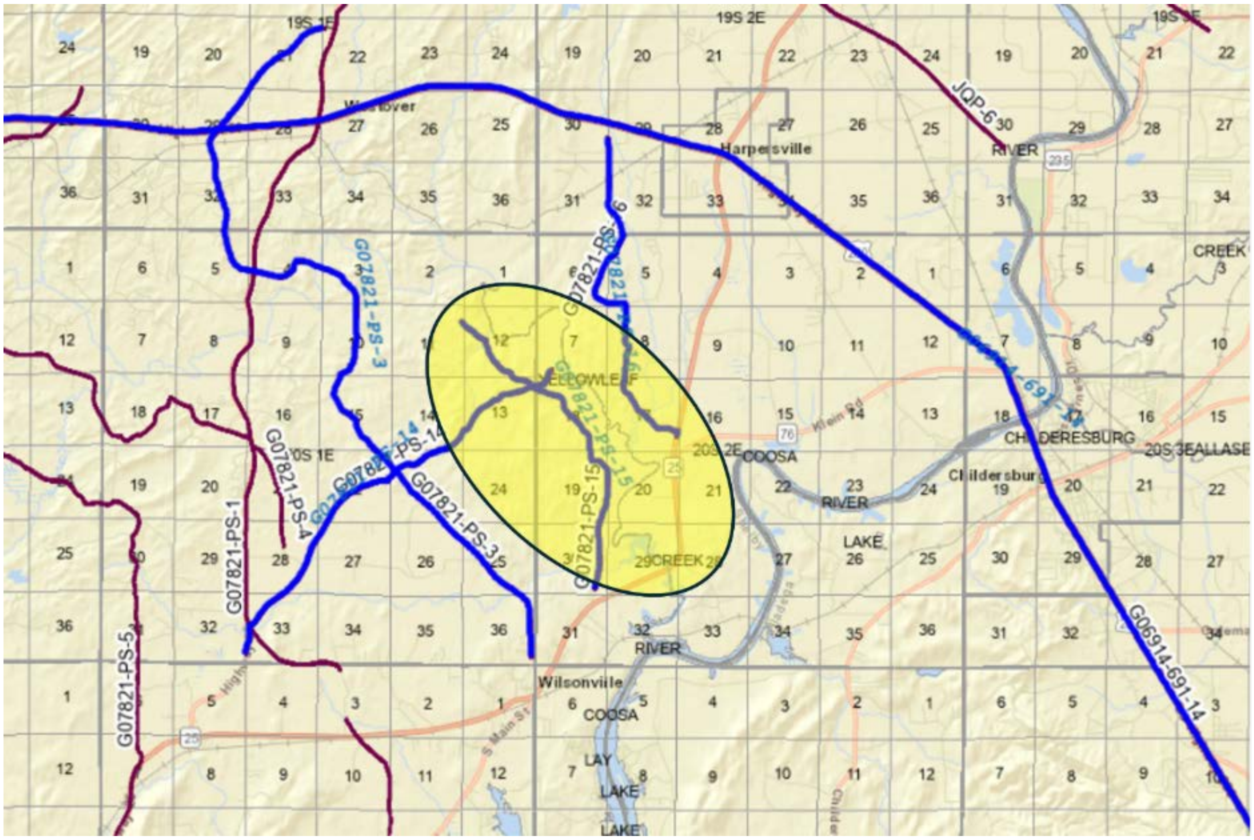

Figure 14. The blue lines indicate 50 line-miles of additional 2D seismic data licensed by SEI.

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6. STATIC EARTH MODEL

Based on logs from the Westover #2 well, the Copper Ridge Member of the Knox Group was evaluated as a fractured reservoir for potential storage. The new seismic interpretation enabled extrapolation of the thrust ramp features across the study area, with a total of 182 square miles now included in the geologic model. The top of the Knox Group, along with each major formation and the top of basement was gridded from these seismic picks **(Figure 15)**.

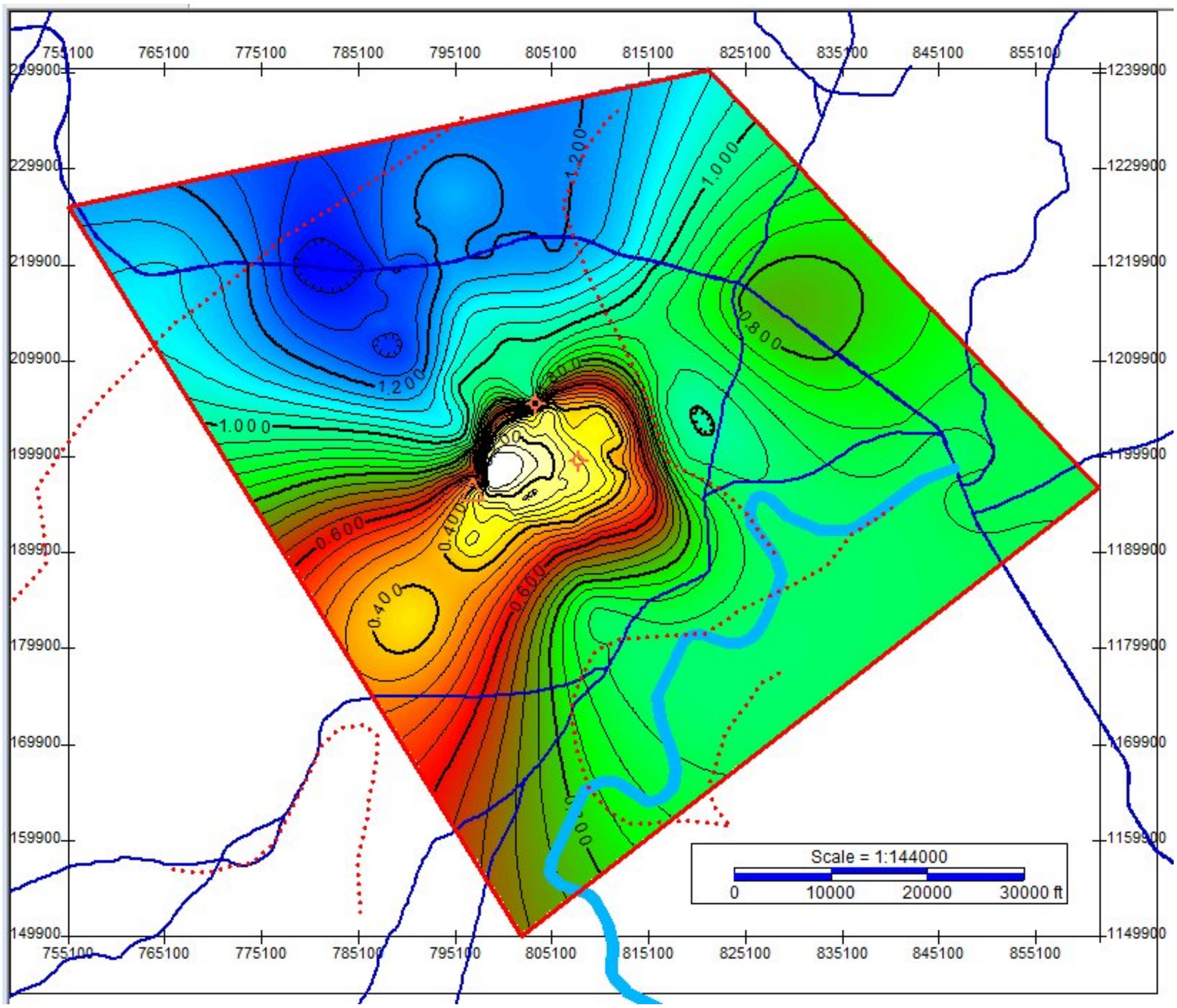

Figure 15. Top of the Knox Group gridded and contoured in Kingdom to show the thrust ramp high.

Well logs were then used to generate a synthetic seismogram, which provided a reliable time-to-depth conversion for the seismic surfaces. The resulting geologic model incorporated both seismic surveys, well data, and regional mapping to create surface maps and a preliminary reservoir framework (**Figure 16**).

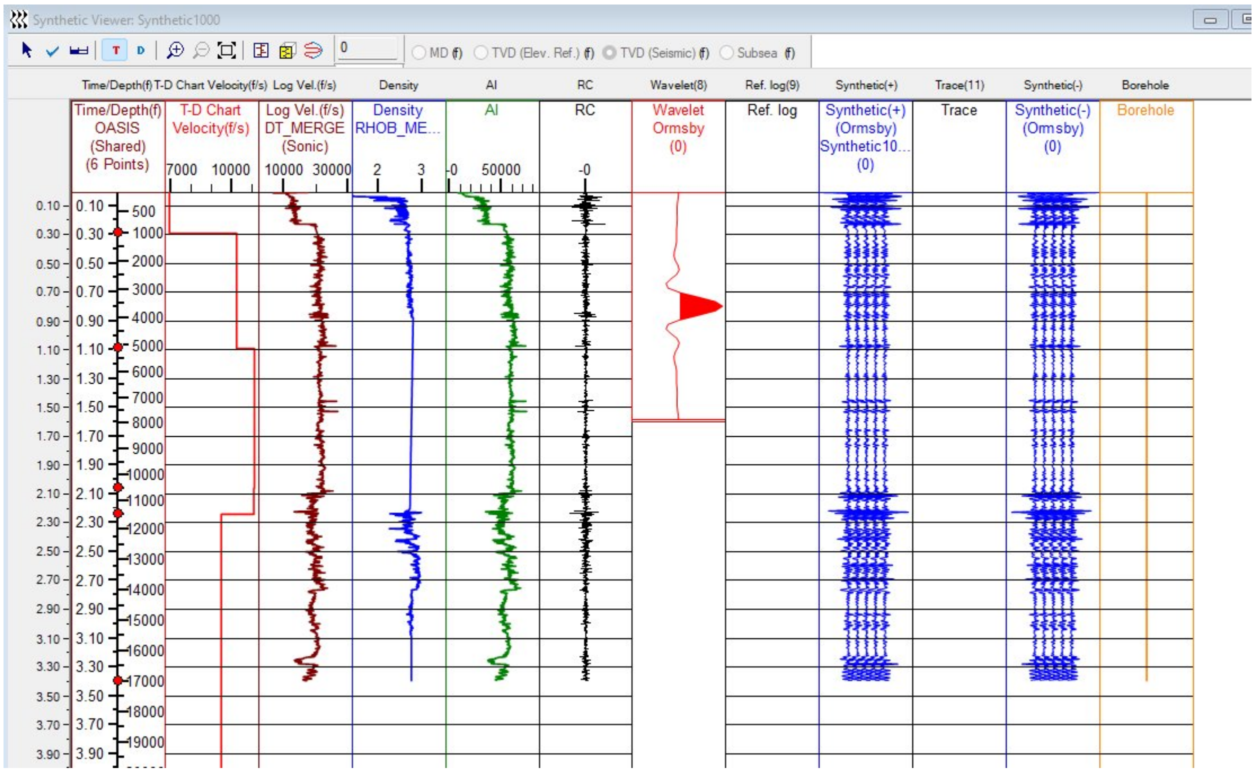

Figure 16. Well logs from the Arco Anschutz #1 are convolved with a wavelet and a time-depth table to create a synthetic seismogram.

7. RESERVOIR SIMULATIONS

Preliminary Model Runs

Reservoir simulations were constructed by using the geologic framework developed in the previous section as input to CMG GEM's Compositional Equation-of-State numerical simulation software. Initial modeling objectives were to obtain potential CO_2 injection rate and mass, coupled with plume area, over the 25 square mile characterized thrust ramp at the location of the Westover #2 well. The system is initially assumed to be a closed boundary due to the regional faulting. Various sensitivities were then conducted on the operating conditions, including the boundary condition, injection gradient, well configuration, and injection targets. These sensitivities give a range of possible injection masses, which are critically important given the sparse data available regionally.

Reservoir Modeling Inputs

Geological analysis was conducted based on collected data from the Westover #1 and Westover #2 wells, which included a suite of well logs. Regionally available well logs and seismic data were also analyzed, along with regional maps and publications. The geological analysis resulted in the reservoir layering described in **Table 1**. Thin, higher permeability and porosity "Sweet Spots" were implemented to high-grade targets and incorporate vertical heterogeneity as suggested by the collected data. Please refer to the geology section for more detail on the data available and geologic analysis leading to the reservoir description provided below (**Table 2**). In the absence of site-specific data, relative permeability curves for carbonates were taken from literature[1], and proprietary data libraries for sandstones. 3D and Cross-Sectional views of the reservoir model are displayed in **Figures 17 and 18**.

Table 1. Reservoir Layering and Properties

Geologic Unit	Top Depth (ft)	Thickness (ft)	Porosity (%)	Permeability (mD)
Knox 1 – Entire Unit	1,740	5,270	0.54	0.24
Knox – Newala Sweet Spot	2,650	20	7.0	2
Knox – Longview Sweet Spot	3,910	20	3.0	2
Knox – Chepultepec Sweet Spot	4,600	25	6.0	2
Knox – Copper Ridge Sweet Spot	5,820	25	6.0	2
Knox 2 – Repeat Section	7,010	4,010	0.54	0.24
Conasauga	11,020	2,510	0.50	0.24
Conasauga - Sweet Spot	12,260	40	4.0	2
Rome	13,530	3,370	2.0	1
Rome – Sweet Spot	14,880	670	10.0	10

[1] Bennison and Bachu (2005)

Table 2. Reservoir Inputs

Parameter	Value	Unit
Initial Reservoir Pressure Gradient	0.433	Psi/ft
Injection Pressure Gradient	0.65-0.80	Psi/ft
Brine Salinity	100,000	Ppm
Reservoir Temperature Gradient	0.0107°F/ft + 70°F	°F

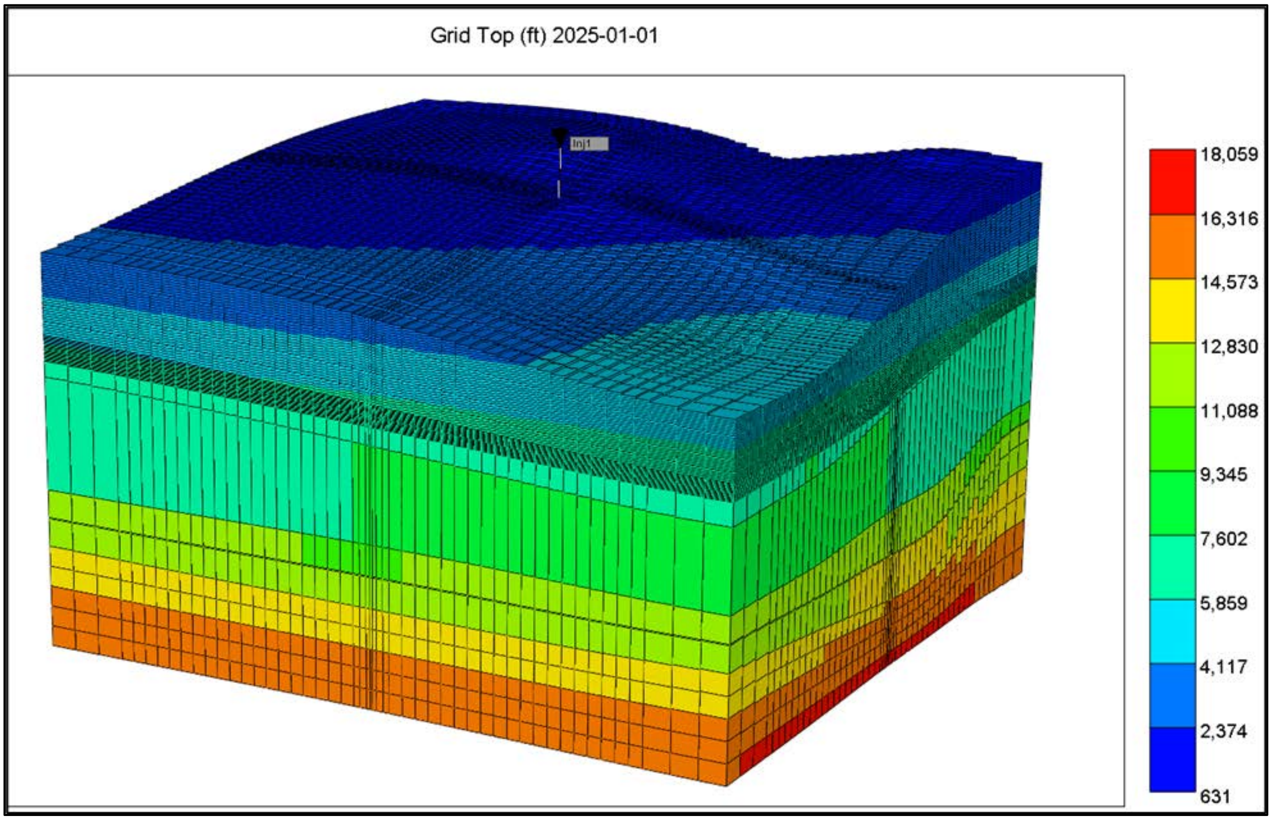

Figure 17. 3D View of Reservoir Model – 5 Miles x 5 Miles.

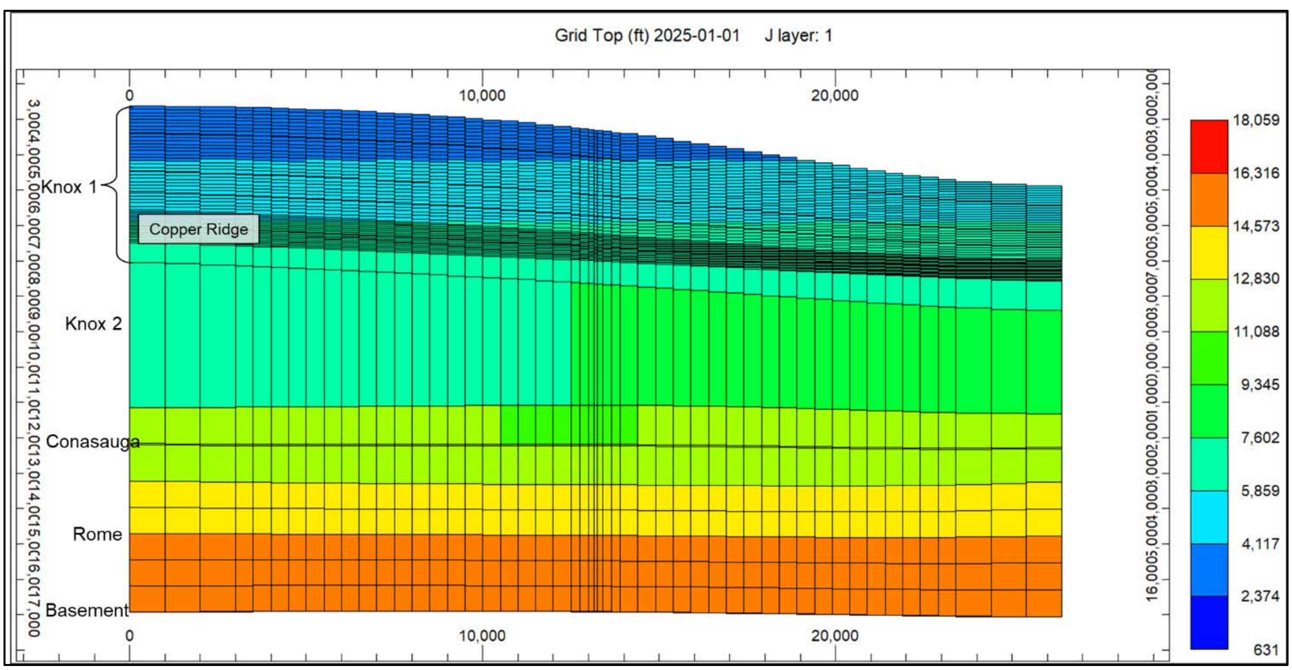

Figure 18. Cross-Sectional View of Reservoir Model Highlighting the Copper Ridge.

First Iteration Reservoir Modeling

For the initial modeling, three simulations were conducted, utilizing a vertical wellbore to target the Copper Ridge, all Knox Sweet Spots, and the Rome Formation. For the Copper Ridge and Knox sections, a thin section of higher porosity and permeability reservoir was implemented, termed “Sweet Spots”. For more detail, refer to **Geological analysis** was conducted based on collected data from the Westover #1 and Westover #2 wells, which included a suite of well logs. Regionally available well logs and seismic data were also analyzed, along with regional maps and publications. The geological analysis resulted in the reservoir layering described in **Table 1.** Thin, higher permeability and porosity “Sweet Spots” were implemented to high-grade targets and incorporate vertical heterogeneity as suggested by the collected data. Please refer to the geology section for more detail on the data available and geologic analysis leading to the reservoir description provided below (**Table 2**). In the absence of site-specific data, relative permeability curves for carbonates were taken from literature, and proprietary data libraries for sandstones. 3D and Cross-Sectional views of the reservoir model are displayed in **Figures 17 and 18.**

Table 1 above which describes the geologic model implemented. All reservoir models are simulated using a maximum bottomhole pressure (BHP) constraint only. Bottomhole injection pressure was limited to 90% of the assumed fracture pressure. Additionally, the simulations were conducted using a closed boundary and a fracture gradient of 0.65 psi/ft. Simulations were conducted with a 30-year injection period, and a 30-year post-injection period. **Figures 19-24** below illustrate the injection profiles over time, along with the cumulative mass injected. In addition, CO_2 saturation is displayed in an aerial view at the end of the 30-year injection period.

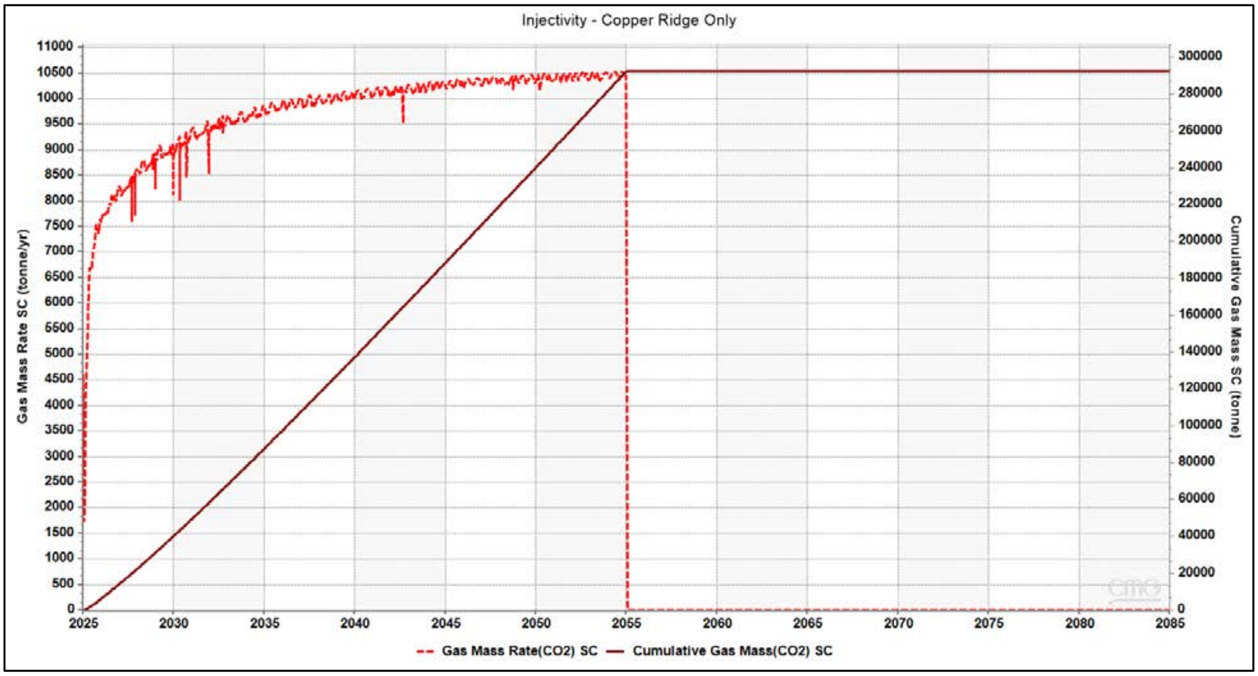

Figure 19. Injectivity Graph of Copper Ridge Sweet Spot Injection.

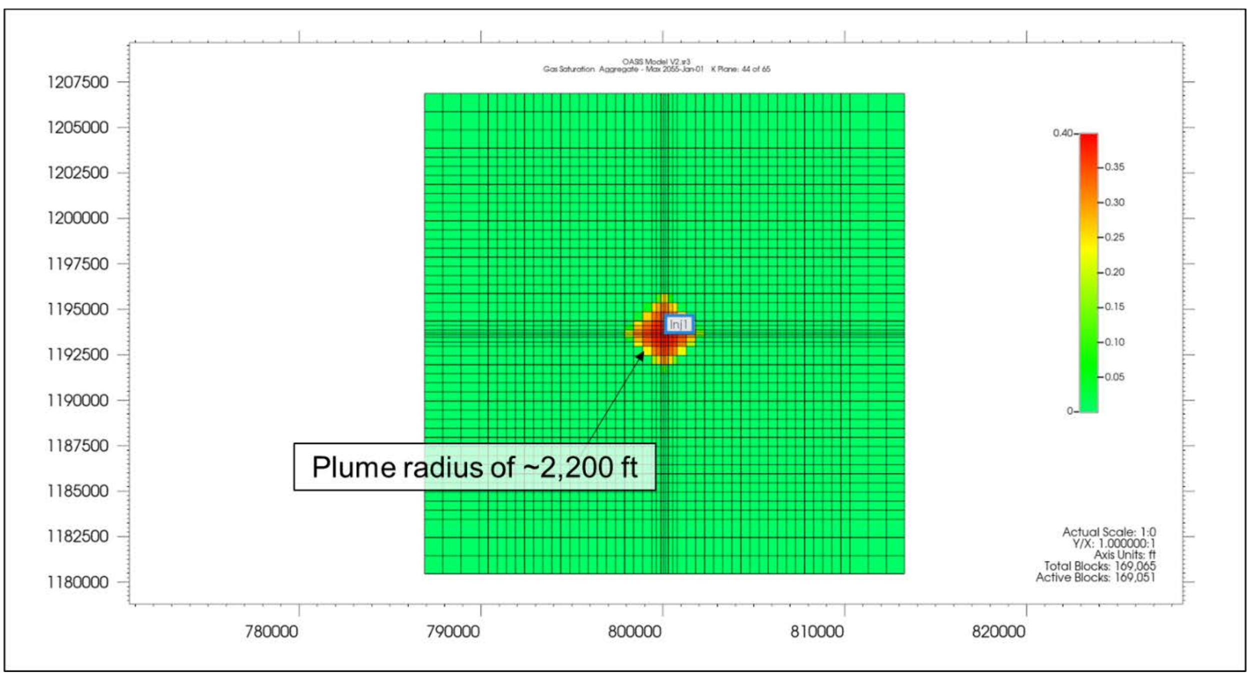

Figure 20. Aerial View of Copper Ridge Sweet Spot CO_2 Plume - Gas Saturation at End of 30-Year Injection.

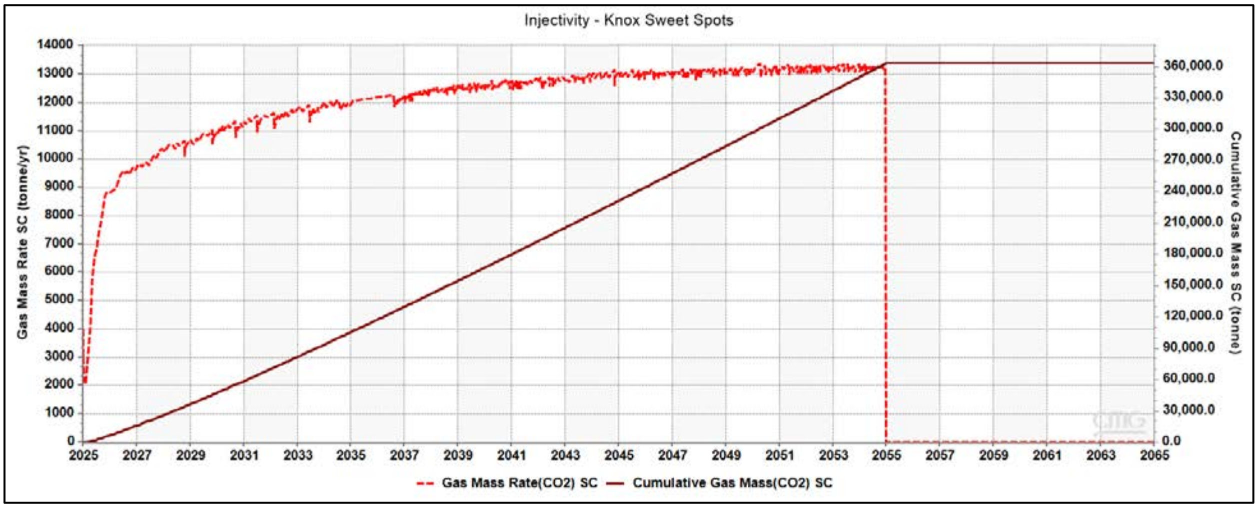

Figure 21. Injectivity Graph of All Knox Sweet Spots Injection.

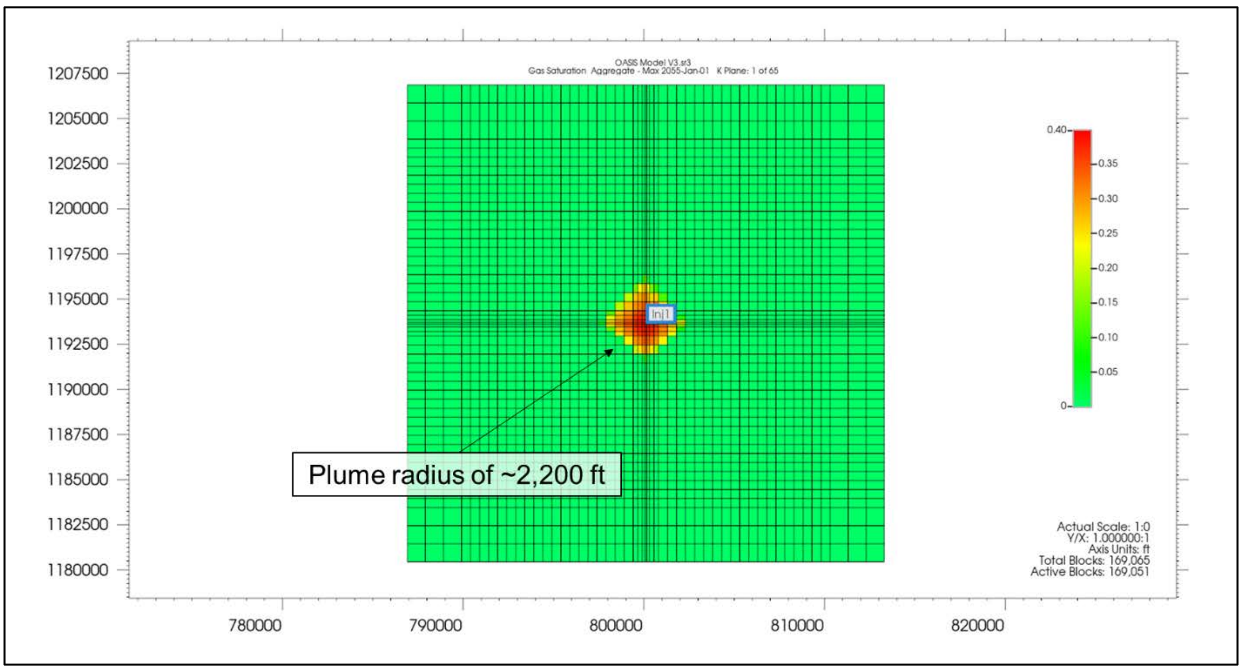

Figure 22. Aerial View of Knox Sweet Spot CO_2 Plume - Gas Saturation at End of 30-Year Injection.

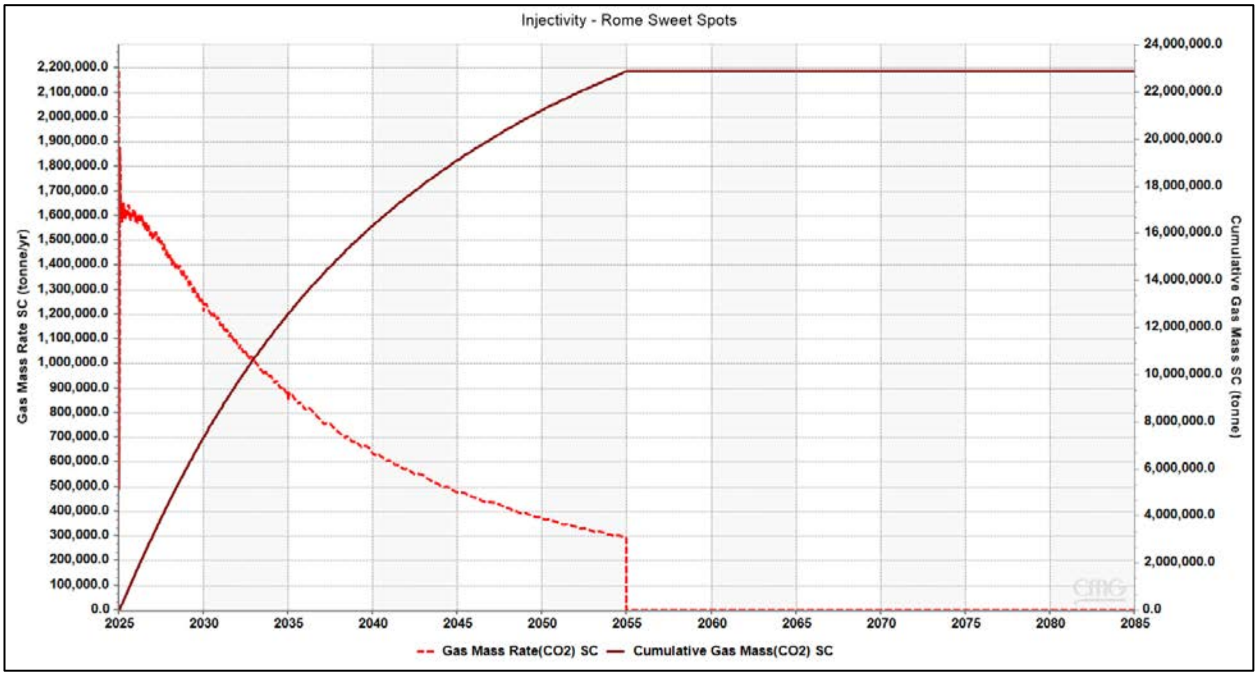

Figure 23. Injectivity Graph of Rome Injection.

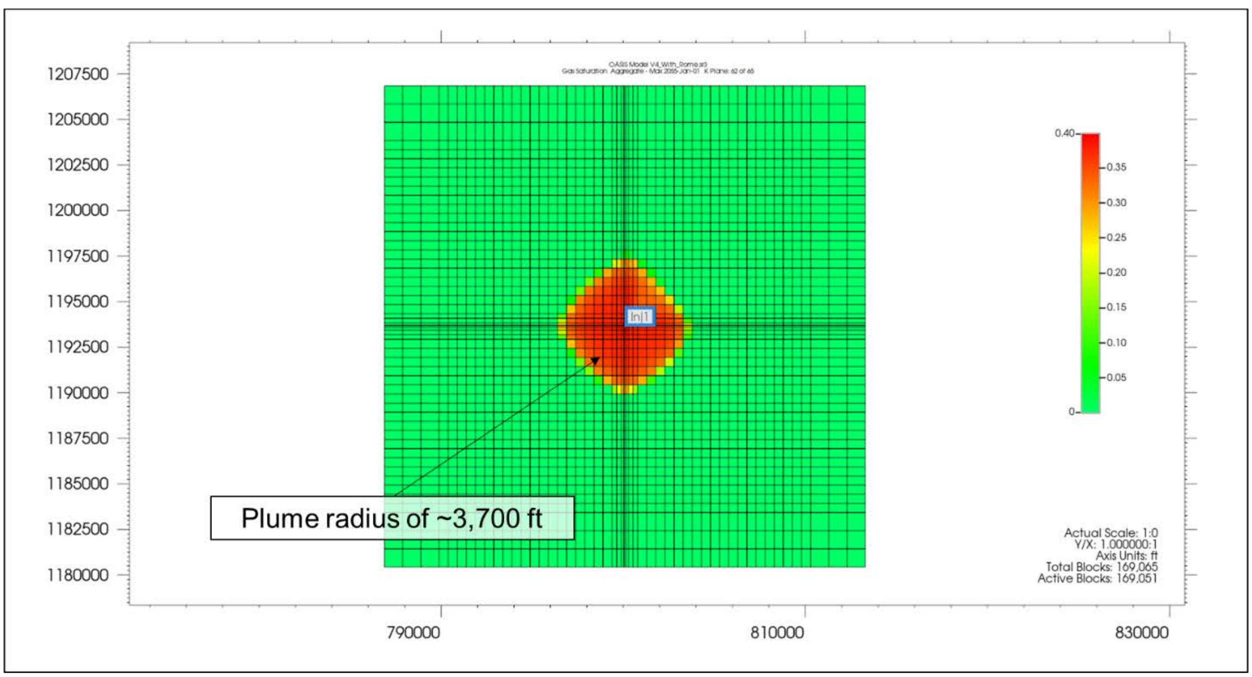

Figure 24. Aerial View of Rome CO_2 Plume - Gas Saturation at End of 30-Year Injection.

Overall, the Knox section is tight with low permeability and porosity. Even in the "Sweet Spots", injectivity is limited by the 2 mD permeability and less than 10% porosity. Early-time injection is limited by the relative permeability effects of injection into a brine system. Over time, injection stabilizes. However, due to the tight conditions, the pressure plume is largely unaffected by the boundary condition. By contrast, the higher permeability of the Rome section allows the pressure transient to reach the model boundary and limits injection over time. The Rome Formation is also significantly deeper (top depth ~13,500 ft), which leads to a greater pressure differential between initial reservoir pressure and injection pressure, while benefitting from a denser CO_2 injectate at reservoir conditions. Initial results suggest that the Knox would provide insufficient storage capacity for CarbonSAFE projects (50 million tonnes over 30 years), but there may be capacity for regional sequestration partnerships. Additionally, the Rome Formation, while much deeper and highly data-sparse, could be a CarbonSAFE target, though the Rome Formation was not sampled directly as part of Project OASIS. More data collection and analysis are required to minimize uncertainty. Injectivity results are summarized below in **Table 3**.

Table 3. First Iteration Modeling Summary Results

Formation	Cumulative Injection, 30 Years (million tonnes)	Average Injection per Year (million tonnes/year)
Copper Ridge ONLY	0.276	0.009
Combination Knox Sweet Spots	0.363	0.012
Rome Injection Only	22.891	0.763

Second Iteration Modeling – Open Boundary on One Side

Additional seismic data was collected which suggests the thrust ramp, previously assumed to be closed on all sides by faults, may be open to the north. To simulate this condition, the model was constructed to be open on one side, which is simulated by adding a large (1,000) volume modifier on one grid edge boundary. However, injectivity is only affected for the Rome Formation, since the Knox pressure plume does not reach the model boundary due to the tight rock properties. **Table 4** summarizes and compares the open boundary on one side to the previous closed boundary models.

Table 4. Comparison of Closed and Open-on-one-side Modeling Results

	Closed Boundary		Open Boundary on One Side	
Formation	Cumulative Injection, 30 Years (million tonnes)	Average Injection per Year (million tonnes/year)	Cumulative Injection, 30 Years (million tonnes)	Average Injection per Year (million tonnes/year)
Copper Ridge ONLY	0.27	0.01	0.27	0.01
Combination Knox Sweet Spots	0.36	0.01	0.36	0.01
Rome Injection Only	22.89	0.76	43.21	1.44

Increased Fracture Pressure Modeling

The sensitivity of the system to fracture pressure is explored by increasing the injection pressure limit to 90% of a 0.80 psi/ft gradient from the starting 0.65 psi/ft gradient. Especially in tight reservoirs, adjustments to the injection pressure can have a large impact on injectivity. For this reason, it is important to collect site-specific data on the fracture pressure of reservoir rock. The three injection scenarios were re-run with the increased pressure limit and are summarized for comparison in **Table 5**.

Table 5. Injection Rates Modeled with Different Pressure Gradients

	0.65 psi/ft Injection Gradient		0.80 psi/ft Injection Gradient	
Formation	Cumulative Injection, 30 Years (million tonnes)	Average Injection per Year (million tonnes/year)	Cumulative Injection, 30 Years (million tonnes)	Average Injection per Year (million tonnes/year)
Copper Ridge ONLY	0.27	0.01	0.55	0.02
Combination Knox Sweet Spots	0.36	0.01	0.85	0.03
Rome Injection Only	22.89	0.76	48.02	1.60

In addition, two new injection scenarios were considered. The maximum potential of the Knox 1 and Knox 2 repeat sections was investigated by numerically perforating and attempting injection into the entire interval. The second scenario involved injection into the Copper Ridge Sweet Spot through a horizontal well with a 5,400 ft lateral section. The figures below show the injection rate of CO_2 as well as the cumulative injection mass for the two scenarios. In addition, plume images are provided to illustrate the CO_2 distribution at the end of injection **(Figures 25-28)**.

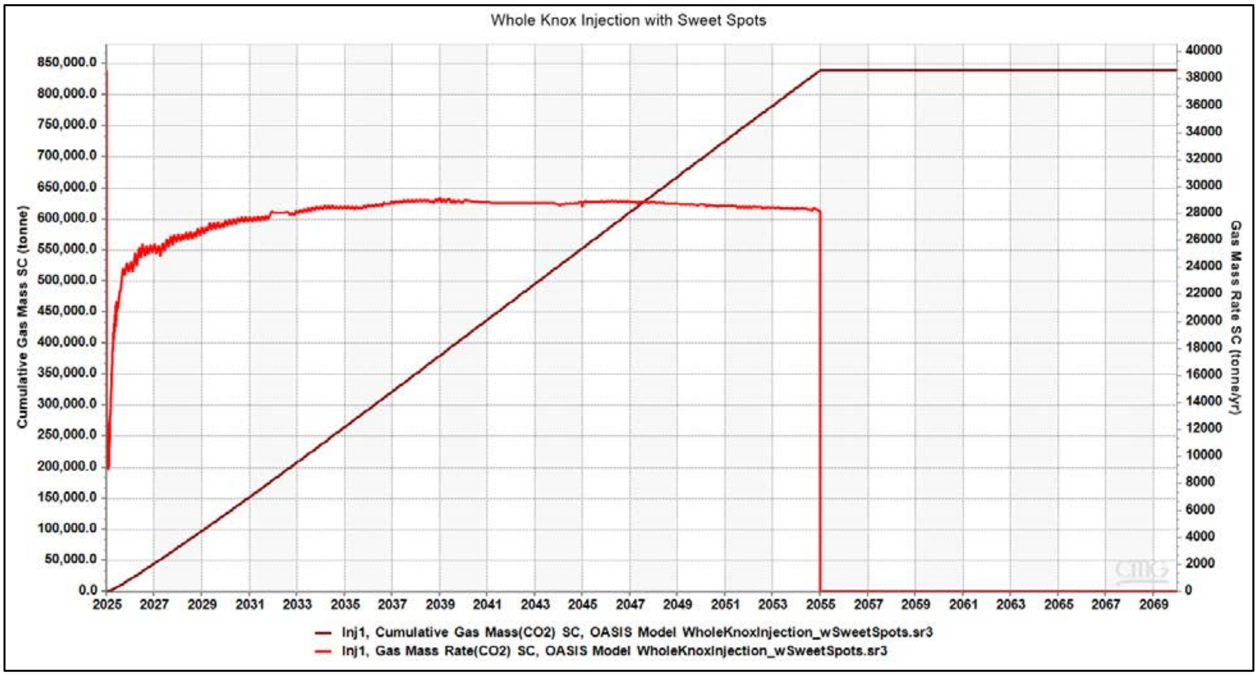

Figure 25. Whole Knox 1 and 2 Interval Injectivity Graph.

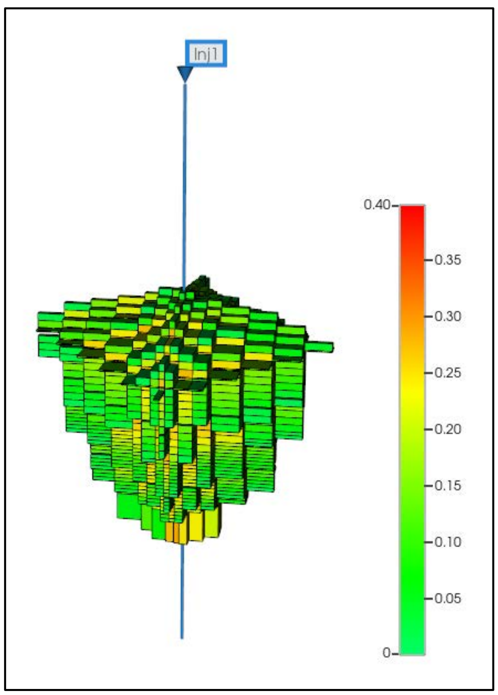

Figure 26. 3D Plume of Whole Knox 1 and 2 Injection - Gas Saturation at the End of 30-Year Injection.

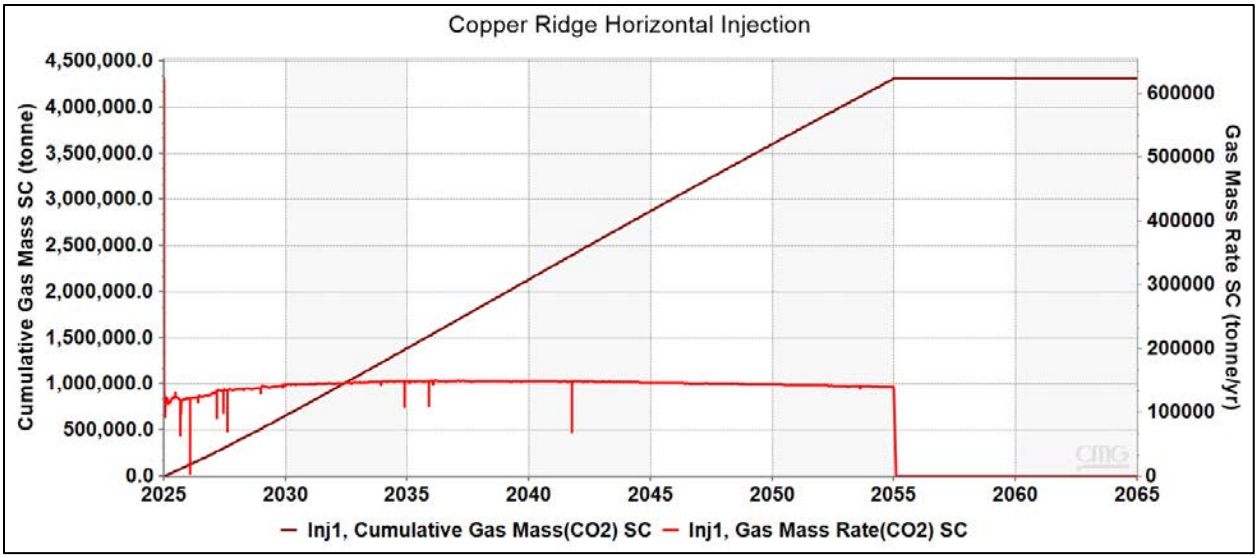

Figure 27. Injectivity Graph of Horizontal Well Injection into Copper Ridge Sweet Spot.

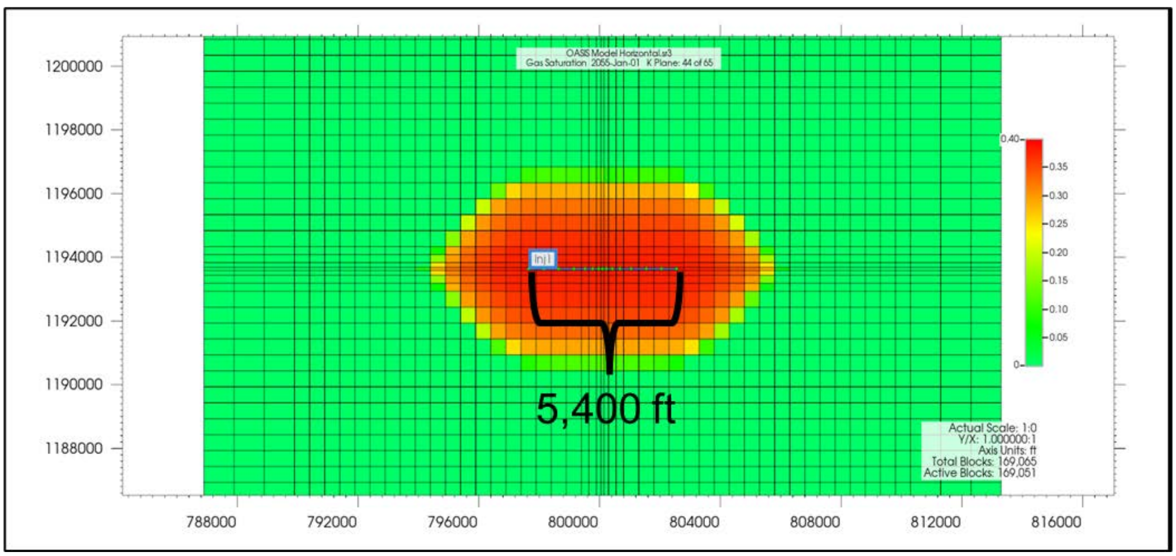

Figure 28. Horizontal Well in Copper Ridge Sweet Spot - Ariel View of CO_2 Plume at the End of 30-Year Injection.

The horizontal well in the Copper Ridge Sweet Spot shows promising results, compared to vertical injectivity in the Knox. Even numerical perforation of the entire Knox 1 and Knox 2 sections did not yield an increase in injectivity, due to the extremely tight formation and decreased bottomhole injection pressure due to shallower perforations. However, drilling a horizontal well in the hard and chert-filled Knox section would be operationally difficult. **Table 6** below summarizes the injectivity of the modeling scenarios utilizing a 0.80 psi/ft fracture gradient. Overall, the Rome Formation has significantly more injection potential than the Knox, but due to the depth and sparse data, further characterization is required.

Table 6. Summary of Injectivity for all Model Scenarios

Closed Boundary			
Formation	**Injection Gradient**	**Cumulative Injection, 30 Years (million tonnes)**	**Average Injection per Year (million tonnes/year)**
Copper Ridge Sweet Spot ONLY	90% of 0.8 psi/ft Gradient	0.55	0.02
Combination Knox Sweet Spots		0.85	0.03
Rome Injection Only		48.02	1.60
5,400 ft Horizontal in Copper Ridge Sweet Spot ONLY		4.31	0.14
Whole Knox Injection (with Sweet Spots)		0.84	0.03

Regional Seismic Updated Runs

The model area was expanded utilizing collected and purchased regional seismic data to interpret the structure over the expanded 182 square mile study area as described in the previous section. Accordingly, new structure maps were created and incorporated into the dynamic reservoir model. The image below shows a 3D view of the reservoir, highlighting the thrust ramp structure. The thrust ramp is interpreted to have a higher degree of fracturing, leading to enhanced permeability and porosity. Accordingly, the reservoir model has incorporated the Knox Fracture

Zones into the model, which have higher permeability and porosity (2 mD and 5% compared to the matrix values of 0.24 mD and 0.54%), but are limited to the thrust ramp area **(Figure 29)**.

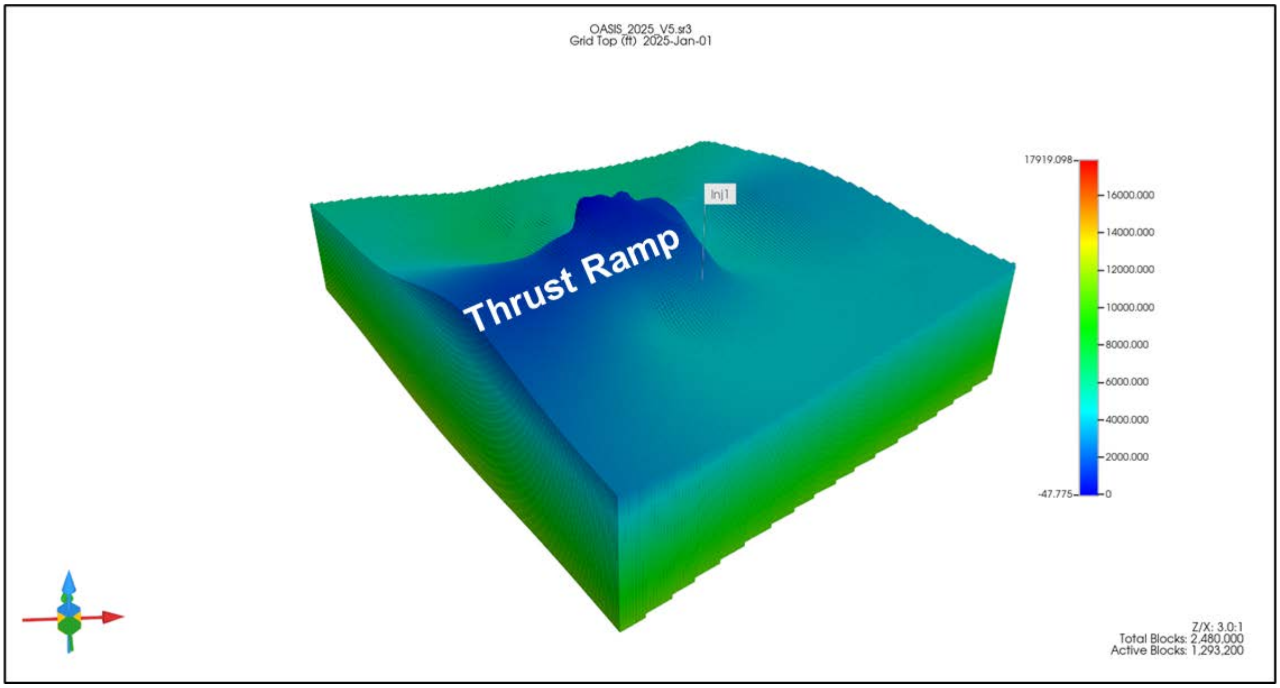

Figure 29. 3D View of Dynamic Reservoir Model (depth, ft).

The Fracture Zone within the Knox is constrained to the Thrust Ramp area. Highlighted in red in the image displayed, this covers the southwest portion of the reservoir model. Permeability (displayed below) and porosity are enhanced as mentioned to 2 mD and 5% in this region compared to the matrix values of 0.24 mD and 0.54% **(Figure 30)**.

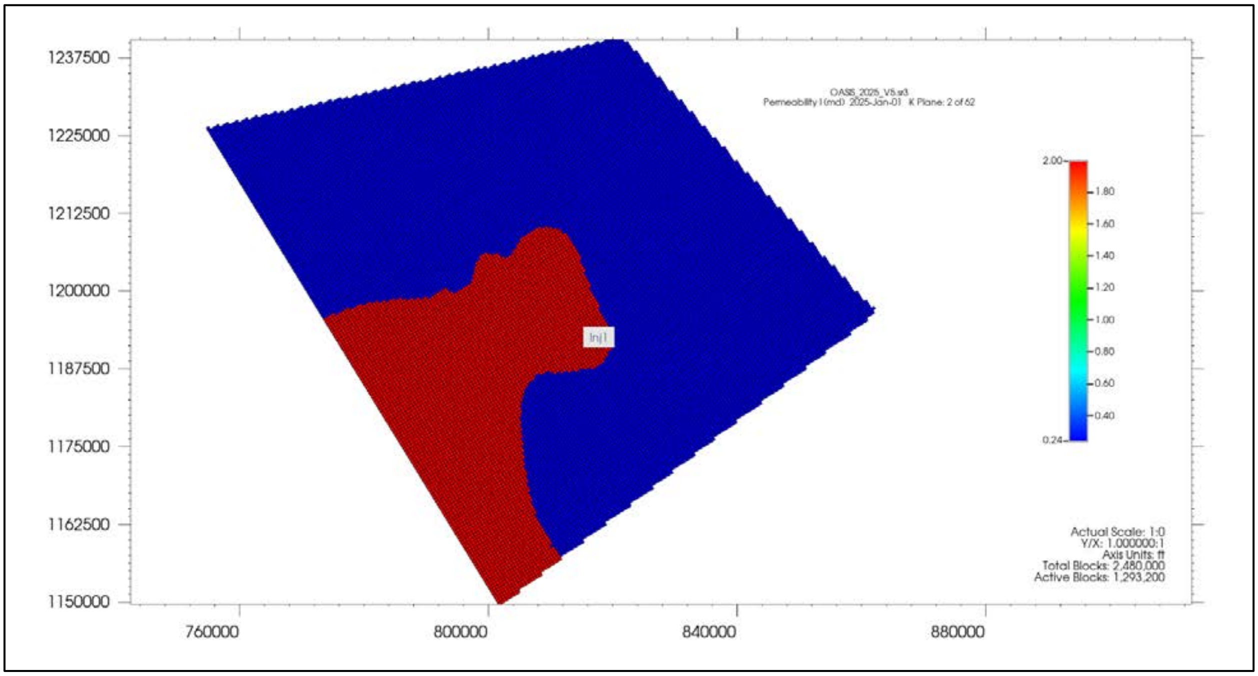

Figure 30. Aeriel View of Thrust Ramp Coverage in Red - Permeability (mD).

The reservoir is assumed to be closed to the northeast (Coosa Deformed Belt) and to the southeast by metamorphic rocks. To the northwest and southwest, an open boundary is approximated by utilizing a volume modification factor of 1,000. The Conasauga permeability and porosity is the same as the Knox, 0.24 mD and 0.54%, respectively. For the Rome, the top 20% of the thickness is simulated as net pay, with 10% porosity and 10 mD permeability. The remainder of the reservoir has 2% porosity and 1 mD permeability. Notably, there is no direct measurement of the Rome Formation, and only regional data has been applied to this highly speculative reservoir at this location. Similar model inputs have been utilized for the updated dynamic reservoir modeling, including a normal pressure gradient (0.433 psi/ft), 0.8 psi fracture gradient, and 100,000 ppm salinity, which are summarized in **Table 7**.

Table 7. Dynamics Reservoir Model Input Parameters

Reservoir Model Inputs		
Parameter	**Value**	**Units**
Initial Pressure Gradient	**0.433**	**Psi/ft**
Fracture Gradient	**0.8**	**Psi/ft**
Permeability	**Varies by Layer**	**mD**
Porosity	**Varies by Layer**	**%**
Injection Pressure Gradient	**0.72**	**Psi/ft**
Grid Cell Size	**500x500**	**Ft**
Temperature Gradient	**0.0107*Depth+70**	**F**
Assumed Salinity	**100,000**	**PPM**

Single well injection scenarios were investigated to explore injectivity for varying parameters. The base model, using the parameters and layering described in the text above and perforating only the Knox Fracture Zone, stabilizes injection at approximately 0.02 million tonnes per year. Sensitivities were then simulated which enhanced the Knox Fracture Zone properties from 5% porosity and 2 mD to 6% porosity and 10 mD, which increased the injection rate to approximately 0.07 million tonnes of CO_2 per year. Using base properties but increasing the fracture zone thickness to 240 ft (three times the thickness) yielded an injection rate of 0.05 million tonnes per year. Another scenario was evaluated utilized the base case, but perforating the entire Knox section, including the fracture zones. This is illustrated in the graph and plume image below and yielded 2-3 times increased injectivity compared to the base case **(Figures 31-32)**.

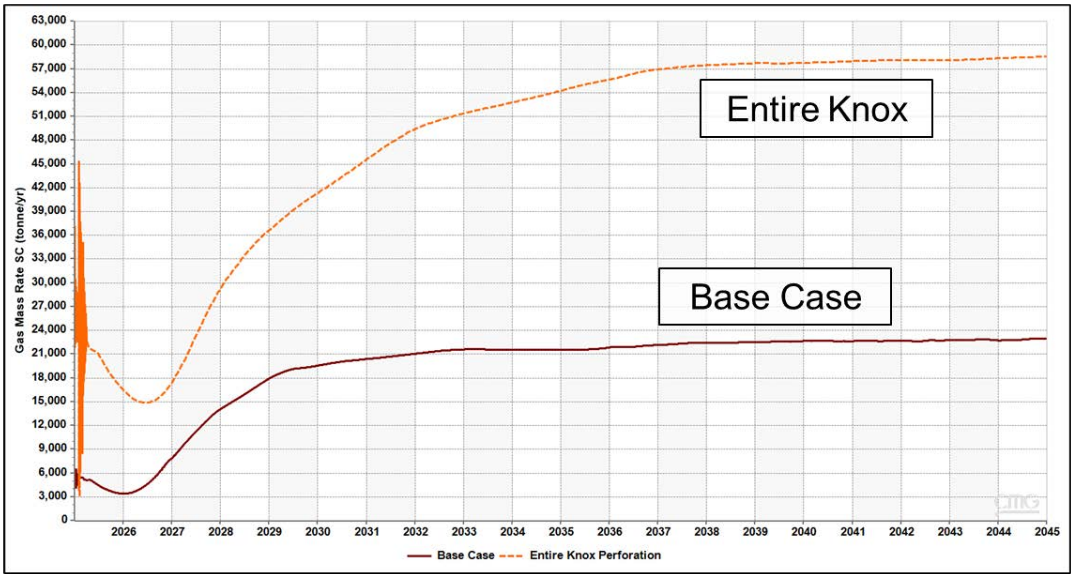

Figure 31. CO_2 Injection Rate Comparison of Base Model and Entire Knox Perforation.

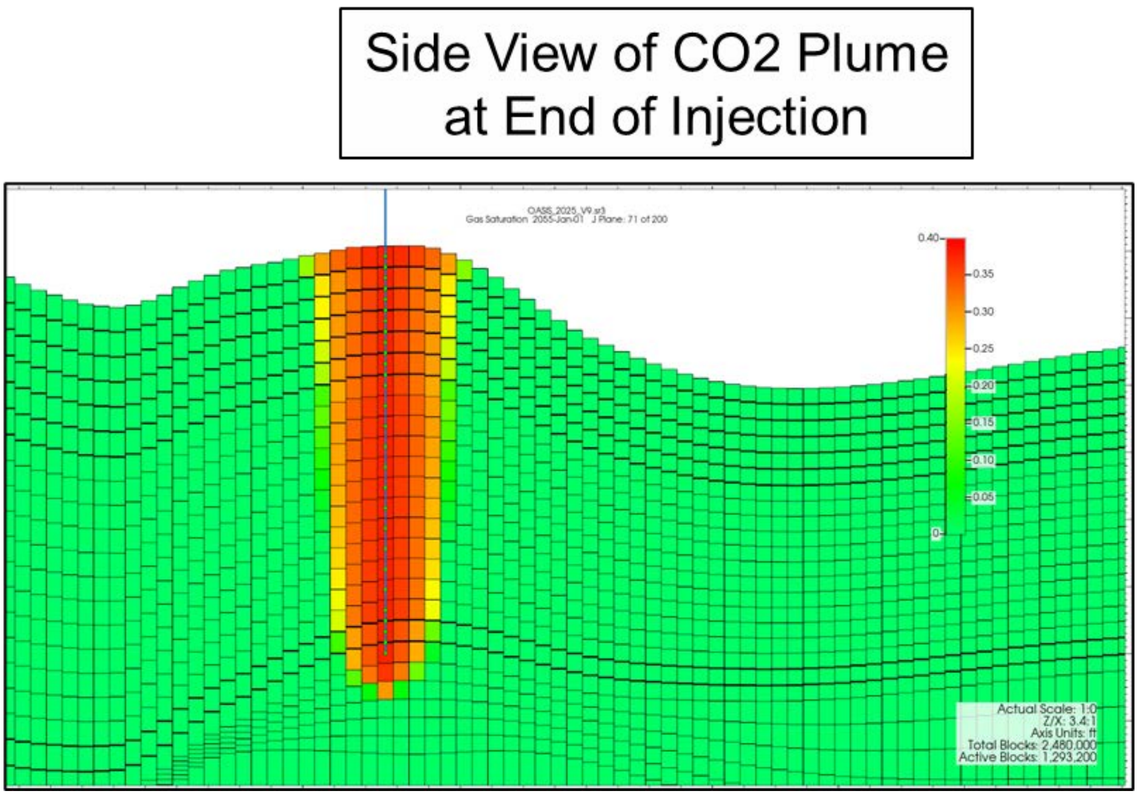

Figure 32. Cross-Sectional View of CO_2 Plume at the End of Injection - Gas Saturation.

The CO_2 plume, as illustrated, is limited in area due to the low injectivity and tight reservoir. Like the CO_2 plume, the pressure plume is also limited in area. The approximate plume radius is 3,250 ft while the pressure plume for the various scenarios ranges from 0.5-1 miles in radius, slightly larger than the CO_2 plume. Perforating the entire Knox section, which could potentially be accomplished with a screen completion, provides maximum access to the tight formation, increasing injectivity by 2-3 times. Due to the tight formation, pressure interference and plume size are smaller, and more wells could be placed to maximize field development, despite the tight reservoir. Overall, injectivity in a single well is limited.

8. UNIVERSITY PARTNERS

Oklahoma State University contributed to the project by conducting seismic structural interpretation and analysis focused on fault and fracture characterization within the Knox Group, with particular emphasis on integrating Formation MicroImager (FMI) log data to better understand subsurface structural features and fracture networks. Auburn University's involvement centered on petrographic and rock property analysis, where two graduate students worked extensively with thin sections and laboratory measurements derived from both whole core and sidewall core samples, as well as comparative material recovered from the Arco Anschutz #1 well, thereby generating valuable insights into reservoir quality, diagenesis, and geomechanical behavior. In parallel, the University of North Alabama played a critical role in workforce development by establishing student internships that provided hands-on training with software donated by Baker Hughes, made available through Project OASIS, ensuring that students gained practical experience to prepare them for their careers.

9. CONCLUSION

The Alabama Valley and Ridge Province presents significant challenges for carbon storage due to its complex geology, tight rock, and low porosity and permeability. While deeper formations may offer additional opportunities, they require further characterization to confirm their suitability and lateral connectivity. The Reservoir Simulation Model, built in GEM from seismic, well, and regional data, covered 182 square miles including a 46.5 square mile thrust ramp structure, and incorporated lithology, fracture zones, and rock property assignments. Results indicate low injectivity, with sensitivity analyses estimating between 20,000-70,000 tonnes CO_2 per year per well. Despite these challenges, the region's proximity to numerous CO_2 emitters without nearby storage options highlights the importance of advancing characterization efforts in areas like the Valley and Ridge, which have traditionally been overlooked for CO_2 storage.