

Southwest Regional Partnership on Carbon Sequestration

Quarterly Progress Report

Reporting Period: July 1, 2014–September 30, 2014

Reid Grigg, PI, Brian McPherson, PI, and Robert Lee, Project Manager

DE- FC26-05NT42591

Recipient: New Mexico Institute of Mining and Technology
801 Leroy Place
Socorro, New Mexico 87801

Table of Contents

Table of Contents	2
List of Figures and Tables.....	3
Executive Summary	5
TASK 1 Regional Characterization	6
Arbuckle Formation	6
TASK 2 Public Outreach and Education	6
Subtask 2.2 Project Website	6
Task 4 Site Characterization and Planning.....	7
Subtask 4.1 Existing Data Gathering and Interpretation	7
Morrowan Reservoir Top, Bottom, and Isopach, Based on Wireline Logs.....	7
Other Characterization Activities	17
Subtask 4.3 Initial Reservoir Model Development.....	17
STOMP-EOR.....	17
Subtask 4.4 Initial Risk Assessment.....	18
CO ₂ -PENS-PSUADE: An integrated Framework for CO ₂ Accounting and Risk Analysis.	18
Simulations and Verification of Different Uncertainty Quantification Approaches	23
Task 6 Operational Monitoring and Modeling	24
Subtask 6.1 Surface and Near-Surface Monitoring	24
Gravity Measurements at the Farnsworth Site.....	24
Eddy Covariance Research	25
Water Sample Analysis.....	25
Data Analysis	25
CO ₂ Surface Flux Monitoring	27
Subtask 6.2 Subsurface Monitoring.....	32
Injection and Production Data	32
Operational Monitoring and Modeling: Geochemical Model	32
Tracers.....	33
Subtask 6.3 Seismic Activities.....	34
Seismic Data Acquisition at FWU.....	34
3D Seismic Interpretation for the Farnsworth Unit	36
Geomechanical Modeling.....	39
Subtask 6.4 Reservoir Modeling.....	40
Geological Model for Reservoir Simulation Study	40
Task 8 Project Management and Oversight.....	49
Field Activities.....	49
Workshops, Meetings, and Conferences.....	51
Other Administrative Activities and Oversight	52
Cost Status	53
Summary of Significant Accomplishments.....	60
Anticipated Delays	60
APPENDICES.....	60

List of Figures and Tables

Fig. 1. Idealized model of Morrow depositional tract at Farnsworth Unit.	7
Fig. 2. Gamma Ray Log from FWU 13-10A showing top of Thirteen Fingers, Top of Morrow Shale, and top and base of Morrow B, left, and expanded view of Morrow B sandstone with core photo to the right.	8
Fig. 3. Right, well #20-2 prior to adjustment. All gAPI readings are below 9 gAPI (American Petroleum Institute gamma ray units). Left, Well #20-2 with gAPI values multiplied by 21.11 in order to bring values into correct range.	9
Figure 4. Morrow-B top based on GR well top picks.	10
Figure 5. Morrow-B base.	11
Figure 6. Morrow-B Isopach map.	11
Figure 7. Variability in rock composition, porosity and pore types, and depth was examined.	14
Figure 8. Ternary diagram of major components in Morrow B sandstones.	15
Figure 9. Paragenetic sequence from Gallagher, 2014.	16
Figure 10. Borehole log data collected from 70 wells in the Farnsworth site.	20
Figure 11. The sampled and modeled semivariograms in vertical (a) and horizontal (b) directions.	20
Figure 12. An integrated framework for uncertainty quantification of CO ₂ -EOR in the Farnsworth Unit.	21
Fig. 13. Locations of CO ₂ flux collars near the center of the FWU west side CO ₂ injection area.	31
Figure 14. 10,000 m × 10,000 m × 95 grid of the Farnsworth field centered on the 1310A injection well.	33
Figure 15. Combined surface-vertical seismic profile and crosswell tomography data.	35
Fig 16. Velocity model output.	37
Fig 17. Variance time slice at -1500 ms.	38
Fig 18. Amplitude contrast time slice at -1620 ms.	38
Fig 19. Ant-track time slice at 1620 ms extracted from the amplitude contrast in Fig 18.	39
Figure 20. A section of the seismic data with 13-10A well during the interpretation (Hutton 2014).	41
Figure 21. Calibration of the well logs from well 13-10A to the seismic data (Hutton 2014).	41
Figure 22. Structural interpretation from seismic data (Hutton 2014).	42
Figure 23. Various Horizons in the model, divided into different layers.	43
Figure 24. Petrel workflow for Property modeling used in building the geological for the Farnsworth field unit.	44

Figure 25. Showing wells with porosity data distributed throughout the field, which are used in the property modeling45

Figure 26. Showing wells with permeability data distributed throughout the field, which are used in the Property modeling. Majority of the core data are concentrated at the East side of the field.45

Figure 27. Well section of scale-up porosity logs for quality check analysis.....46

Figure 28. This histogram shows the interpolated porosity together with upscale log data and raw well log data.47

Figure 29. This histogram shows the interpolated permeability together with upscale log data and raw well log data.47

Figure 30. 3-D Porosity distribution onto the fine grid. This is the distribution in layer 7.48

Figure 31. 3-D Permeability distribution onto the fine grid. This is the distribution in layer 7. ...49

Table 1. Water Sample Analyses26

Table 2. CO₂ Surface Flux Data28

Table 3. Summary of CO₂ Injection.....32

Table 4. Project Budget and Expenditures for the Quarter July 1–September 30, 201454

Table 5. Milestone Plan Status.....55

Executive Summary

Tasks addressed in this quarter were Tasks 1, 2, 4, 6, and 8.

Task 1–Regional Characterization: Researchers finished the map of the depth to the top of the Arbuckle Group, which will be allied to volumetrics in order to estimate CO₂ disposal.

Task 2–Public Outreach and Education: Researchers continued to assist with contact email for the SWP website and to implement the Velo data-sharing system. They also assisted with the recovery of files from the SWP Project data-sharing site Velo, due to the deletion of the SWP files that occurred while a user was connected to Velo by the WebDAV sharing protocol.

Task 4–Site Characterization and Planning: Researchers made progress in the geologic characterization of the FWU. Coordination of the core analysis continued. The STOMP-EOR simulator is now functioning as an executable; verification testing continued. A STOMP-EOR workshop was held September 30–October 1 at the University of Utah. CO₂-PENS-PSUADE: researchers first conducted a geostatistical analysis of the well-log data collected from 70 boreholes of the FWU and then developed an integrated framework for understanding CO₂ storage potential within an EOR environment. The project team continued to work on simulations and verification of uncertainty quantification approaches.

Task 6–Operational Monitoring and Modeling: Researchers took measurements of gravity, self-potential, micro-seismicity and weather, and conducted basic studies for improving in-situ monitoring and data analysis methods. The project team continued to work on surface and near-surface monitoring tasks, addressing the visualization and analysis of eddy flux data at the site with an open-source package, “openair”. Background CO₂ surface flux was taken from specific sampling locations. Work on the geochemical model focused on extending TOUGHREACT reactive transport simulations. SWP researchers worked on finding a solution for vapor-phase tracer sampling at Farnsworth. A 3D VSP and crosswell tomography processing review meeting took place in Houston on July 9. In the field, coring and logging operations on the FWU 32-08 well were finished. By the end of the quarter, erratic DTS readings from the FWU 13-10A and 13-10 wells were fixed, but noise was still occurring in the passive seismic array. By the end of the quarter, SWP researchers determined that installation of downhole gauges in E Farnsworth was not possible due to numerous casing leaks discovered while preparing the well. Work was performed on high-resolution 3D seismic cube data interpretations to improve geologic and structural understanding of the CO₂ reservoir system. Researchers continued to study key potential geomechanical processes in the Morrow formation and the associated effects on CO₂ capacity and injectivity. A geological model was constructed from the 3-D seismic interpreted surfaces.

Task 8–Project Management: Well 3208 had the intermediate drilling, open hole logs, and intermediate casing completed and 267 ft of core taken. The new well, 1315, displayed increasing production since April; by mid-August it was producing over 400 barrels/day; a case of drilling into a trapped secondary oil bank. Two new Ogallala water sampling site were added and an additional series of CO₂ soil flux samples and were taken with no out-of-normal flux readings. Aqueous tracer samples were also taken. Efforts to determine which well in the 3208 pattern will be used as a downhole sensor/observation well continued. A number of workshops, meetings, and conferences were held, attended, or planned. Working Group activities progressed on schedule for the quarter.

TASK 1 Regional Characterization

Arbuckle Formation

Researchers finished the map depicting the depth to the top of the Arbuckle Group, which will be allied to volumetrics in order to estimate CO₂ disposal. Bottomhole temperature data acquisition is nearly finished with the eastern Townships and about 65% finished with the western Townships.

TASK 2 Public Outreach and Education

Subtask 2.2 Project Website

SWP researchers assisted with the Domain Name System (DNS) and registration of the SWP Internet presence. They continued to assist with contact email for the SWP website and to implement the Velo data-sharing system. Researchers also assisted with the recovery of files from the SWP Project data-sharing site Velo due to the deletion of the SWP files that occurred while a user was connected to Velo by the WebDAV sharing protocol. Researchers prepared for the combined SWP Simulation workshop and core viewing event in Salt Lake City on September 30 – October 2, 2014. The preparations included lodge, catering service, transportation, computer laboratory reservation, website creation, and STOMP-necessary software installation on the lab computers.

During the quarter, work associated with the SWP-Velo element of the project continued to be maintenance of the core software and user support. The SWP-Velo framework is now operational and most of the SWP research team are registered users. The SWP-Velo team maintains the core software