Modeling and Evaluation of Geophysical Methods for Monitoring and Tracking CO_2 Migration in the Subsurface

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Developing the Technologies and Building the Infrastructure for CO_2 Storage
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Presentation Outline

- Benefit to the Program
- Project Overview
- Technical Status
- Accomplishments to Date
- Summary

Benefit to the Program

- Program Goal:

  Develop technologies to demonstrate that 99 percent of injected CO_2 remains in the injection zones

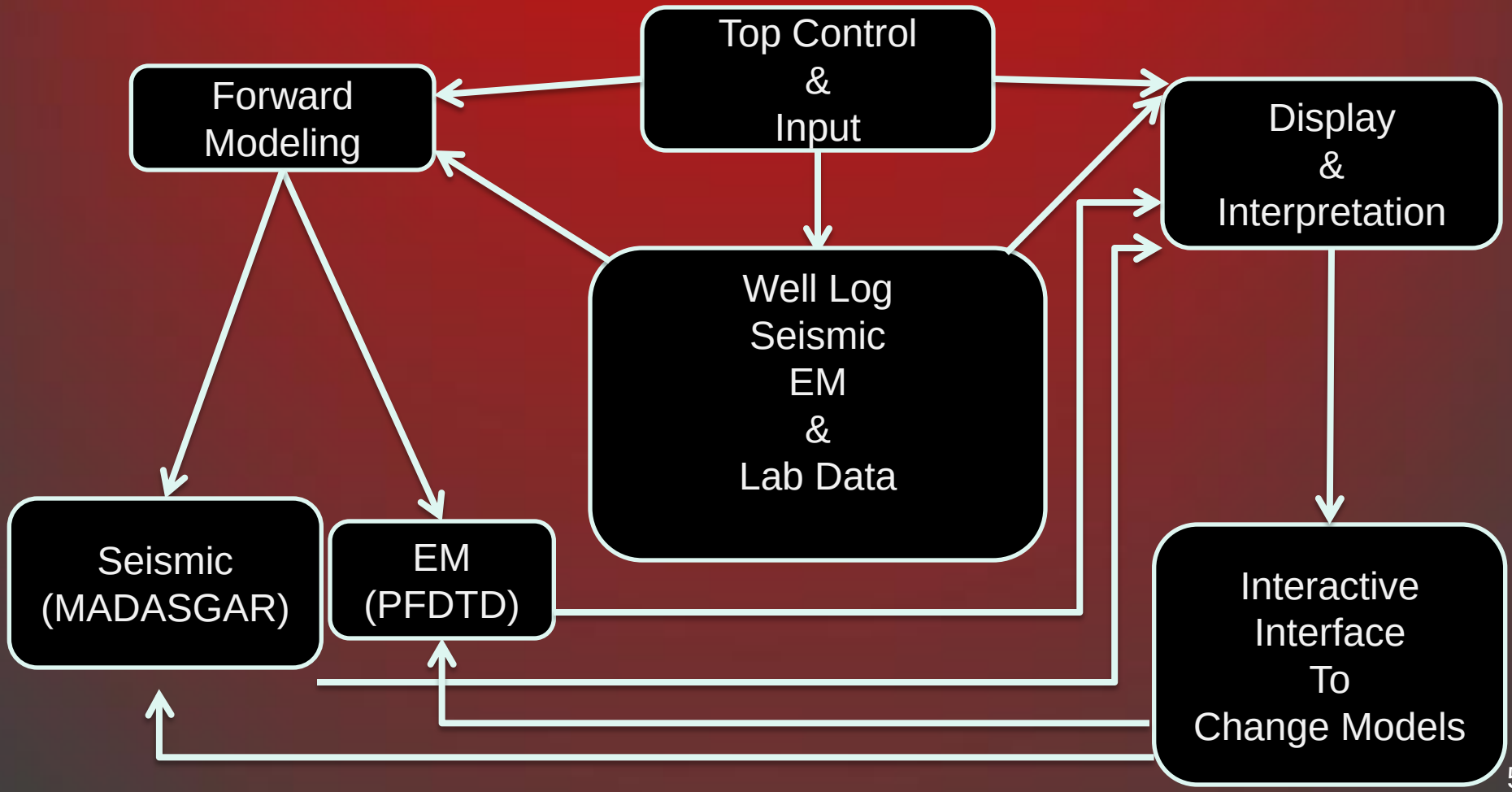
- Project Benefits Statement:
  - Development of a software package to study and improve geophysical methods for monitoring injected CO_2. The software integrates seismic, electromagnetic, and well log methods to aid in field survey design and define limitations that will advance the capability to prove that 99% of injected CO_2 remains in zone.

Project Overview: Goals and Objectives

- Develop a 3D modeling, imaging, and interpretation software package for seismic, EM, and borehole methods.
  - Criteria: Compare software output to literature and field data.
- Collect data from a potential injection site and design heterogeneous injection models.
  - Criteria: Choose a site, collect data, and create data models.
- Produce numerical simulations of the test site that include various injection and monitoring scenarios.
  - Criteria: Output numerical models for imaging and interpretation.
- The Project Goals serve to advance monitoring techniques thus achieve the program goal of demonstrating that CO_2 remains in the injection zone.

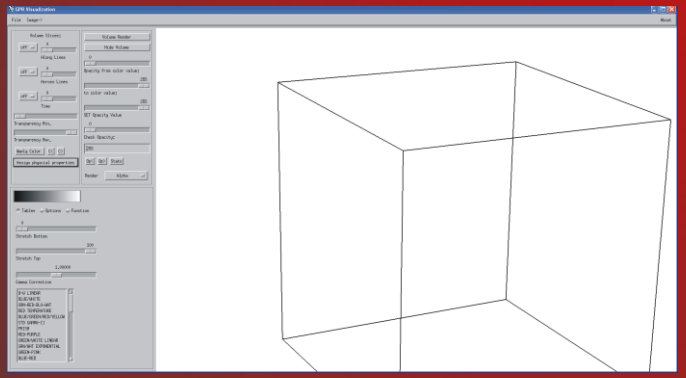
Software Development: GphyzCO2

Open-source software package that utilizes well log, laboratory, Electromagnetic, and Seismic data for analysis and forward modeling.

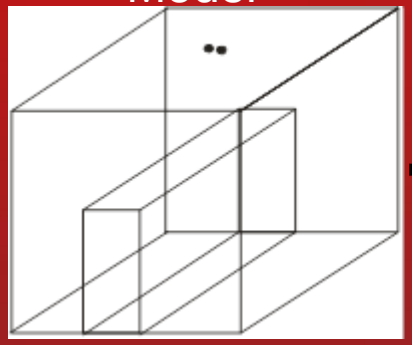


Software Development: Electromagnetic Module

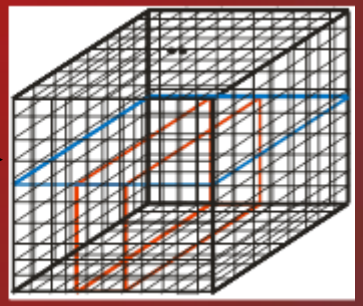
Interface



Model



Sub-block Generation



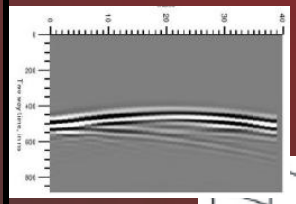
Interface Output

Input to Computational Cluster

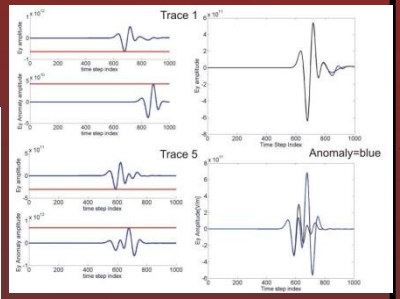
PFDTD Computation

Output Plots

2D



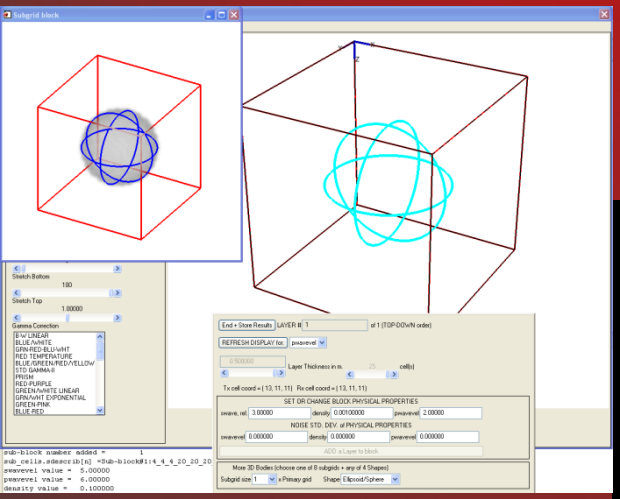
3D



Diagnostic Plots

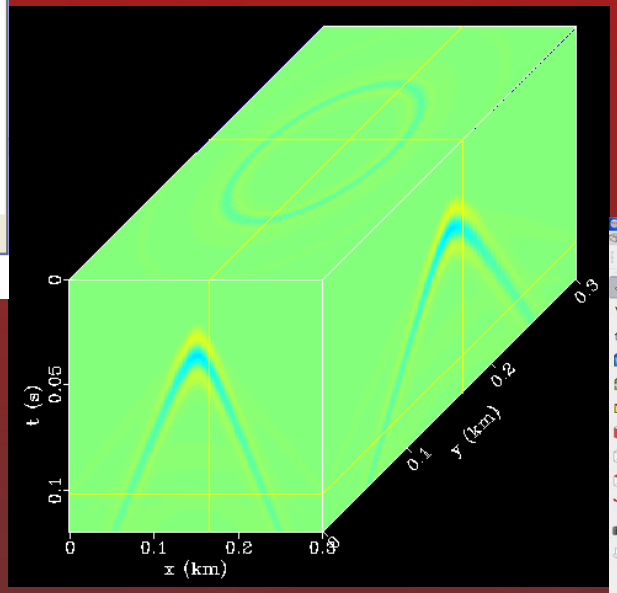
Software Development: Seismic Module

Interface: Model Building



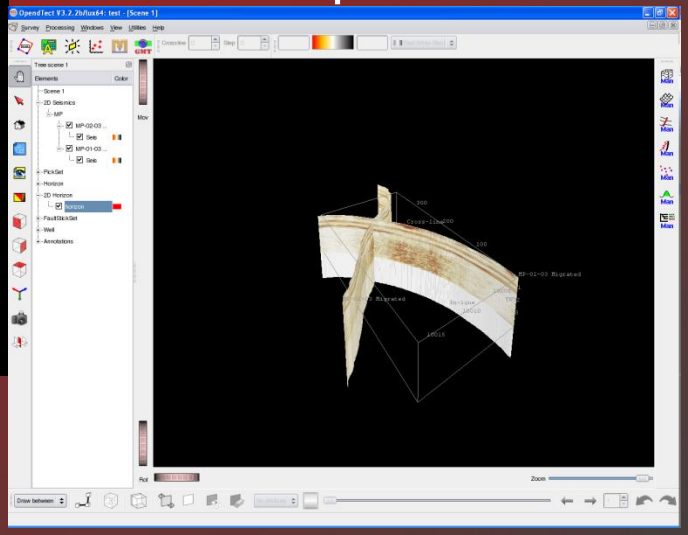
Vp, Vs, Density

Madagascar Forward Modeling

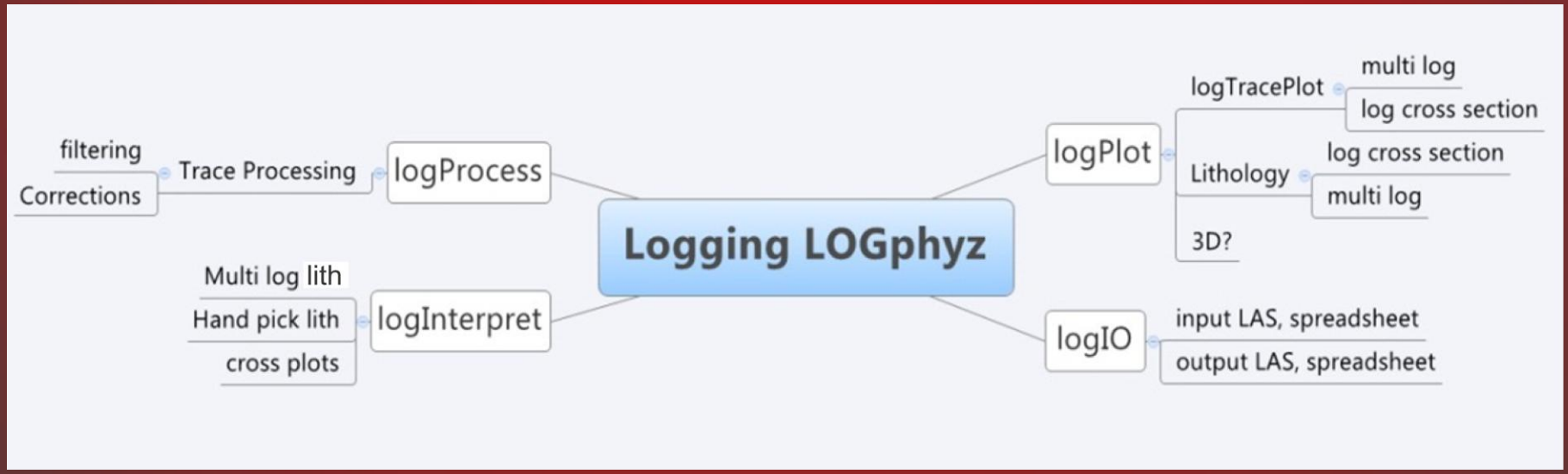


Elastic Anisotropy FDTD

OpendTect Processing, Imaging, and Interpretation



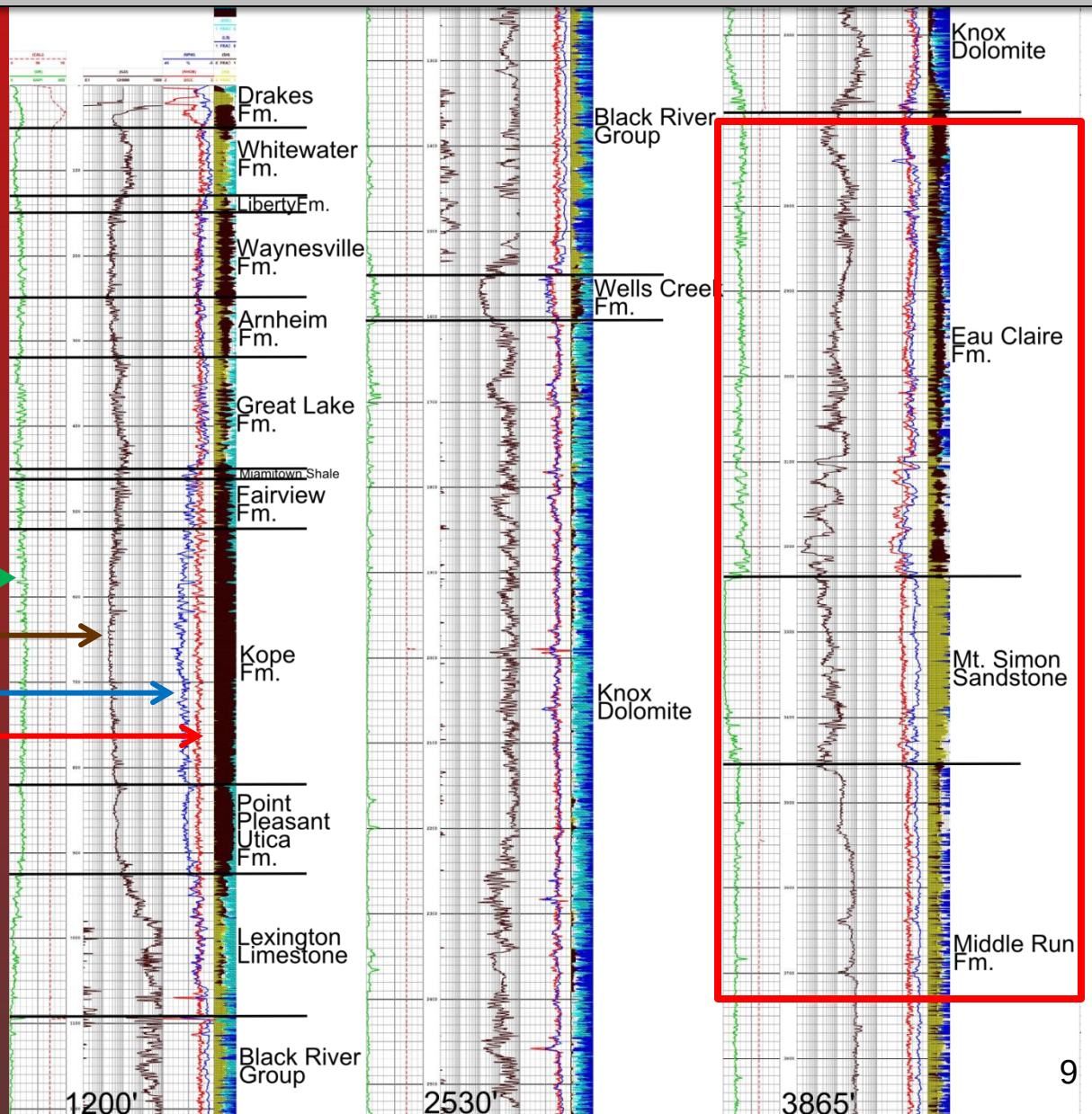
Software Development: Well Log Module



- Geological Characterization
- Borehole Manipulation

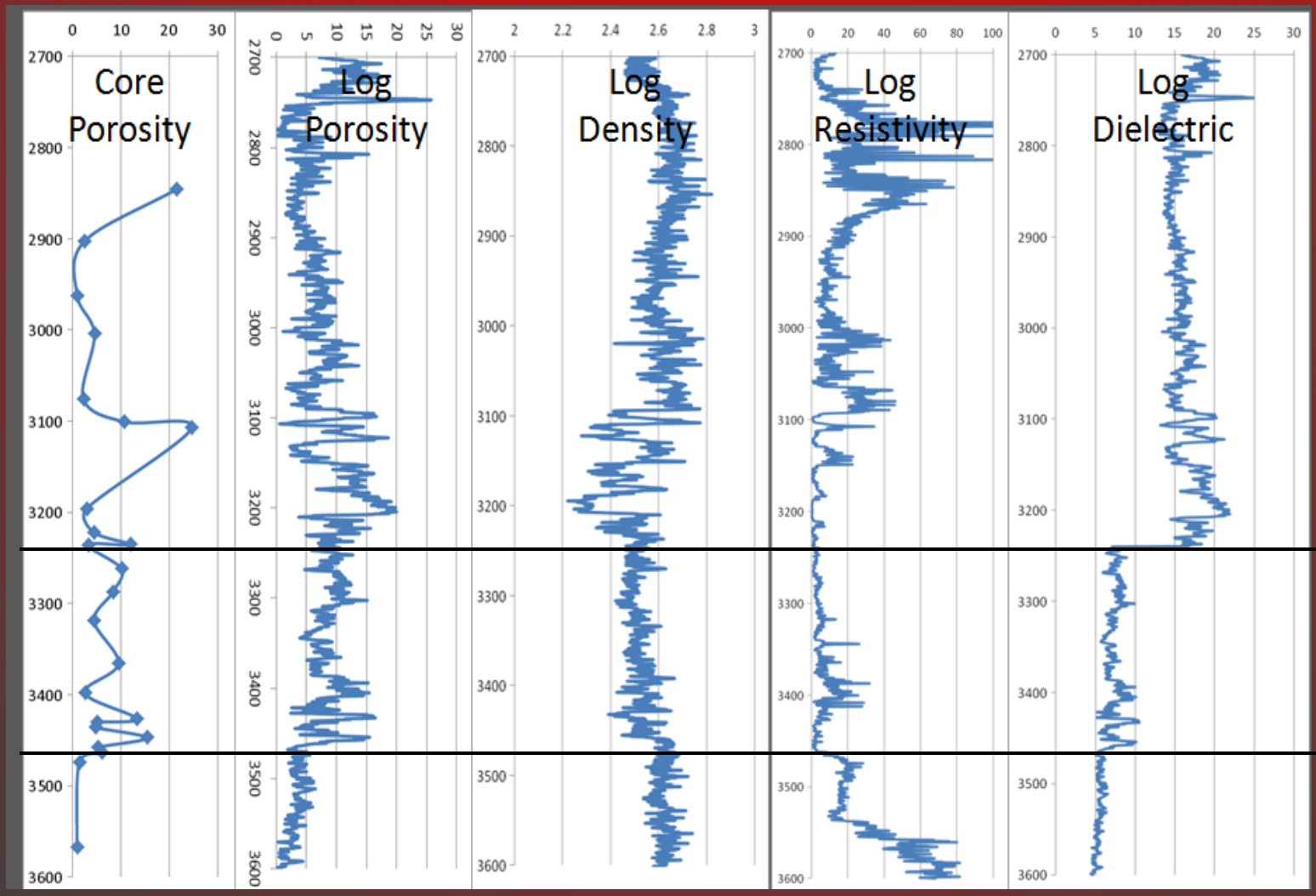
Test Site: Warren Co., OH

GR
Resis
NPhi
RHOB



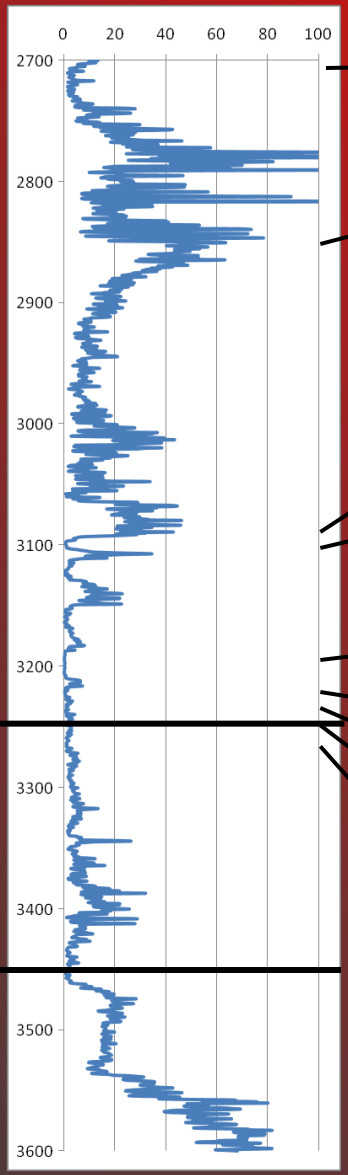
Warren Co.
Well 2627

Test Site Data



Test Site Data

Log Resistivity



Eau Claire Formation

Mt. Simon Sandstone

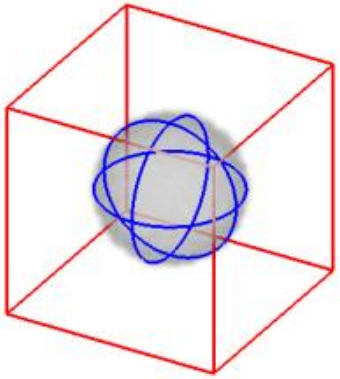
Middle Run Formation

Core Resistivity

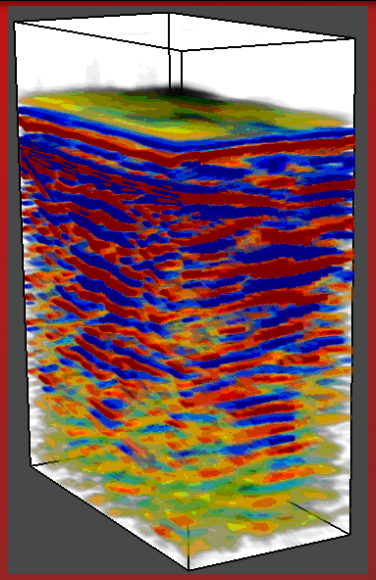
Depth	Unit	Lithology	Resistivity (ohmm)
2710.1	Eau Claire	Mudstone	22.0
2845.75	Eau Claire	Siltstone	23.8
3100.7	Eau Claire	Siltstone	23.5
3107.7	Eau Claire	Sandstone	10.0
3196.2	Eau Claire	Sandstone	5.9
3221.95	Eau Claire	Mudstone	21.8
3235.8	Eau Claire	Siltstone	10.9
3257.4	Mt. Simon	Sandstone	11.5
3269.45	Mt. Simon	Sandstone	12.3

Numerical Modeling

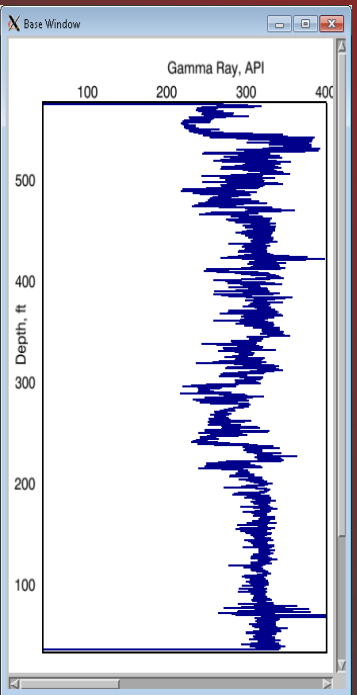
Data Model



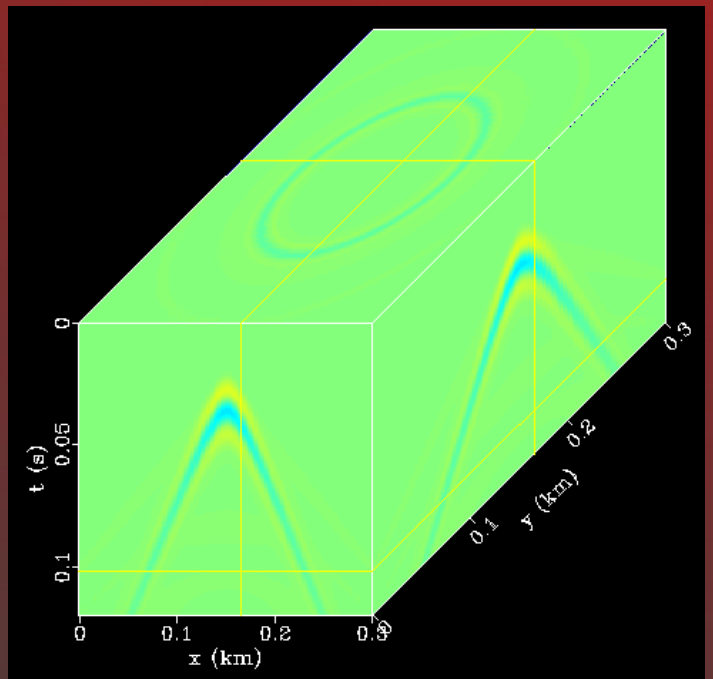
Combine Data



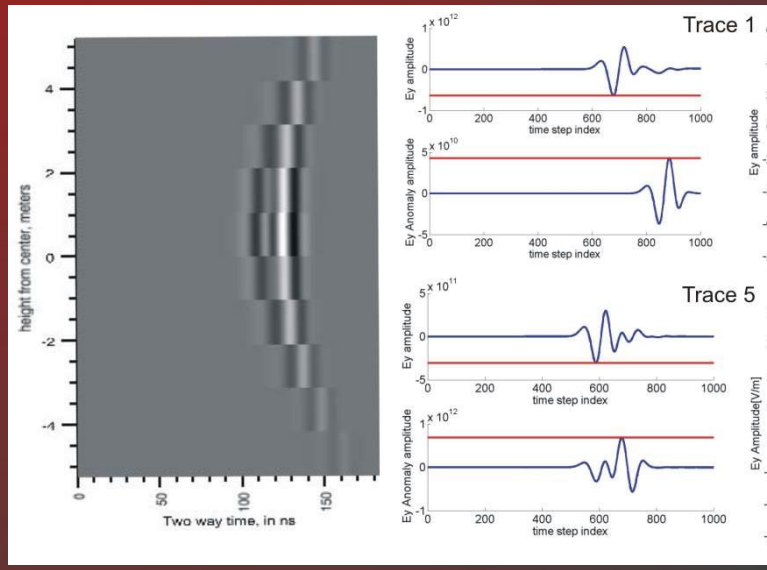
Well Log



Seismic



EM



Accomplishments to Date

- Continuous development of GphyzCO2 software package
  - Completed the Top-Level program
  - Completed the EM modeling and interpretation Module
  - Successfully integrated seismic module with Madagascar and OpendTect.
  - Input and displayed well log data files

- Selected Warren Co. as test site.
  - Collected field and laboratory data.
  - Identified and analyzed injection zone for numerical simulations.

Summary

- Achieve the program goal of demonstrating that CO_2 remains in the injection zone by advancing geophysical monitoring techniques.
- Develop a 3D modeling, imaging, and interpretation software package for seismic, EM, and borehole methods.
- Collect data from a potential injection site and design heterogeneous injection models.
- Produce numerical simulations of multiple injection and monitoring scenarios for the test site.
- Define monitoring methods limitations and design ideal surveys for any potential injection site.

Appendix

- Organization Chart
- Gantt Chart
- Bibliography

Organization Chart

- PI: Jeffrey Daniels
  - Responsible for managing the project and reporting.
- Co-PI: Franklin Schwartz and Robert Burns
  - Advise the project team, help to provide review and guidance to students and contribute to publications.
- Student: Kyle Shalek and Michael Murphy
  - Directly involved in all phases of the research.

Gantt Chart

Task	Year 1				Year 2				Year 3				Completion
1.0 Project Management Plan and Reporting:													90%
2.0 Develop Top (System) Level Program:													100%
3.0 Develop a Wireline Interpretation Module:													75%
4.0 Develop Geologic Characterization Module:													75%
5.0 Develop Seismic Data Interpretation Module :													100%
6.0 Develop Electromagnetic Data Interpretation Module to integrate with the seismic module:													100%
7.0 Develop Wellbore Manipulation Module:													90%
8.0 Develop Additional Modules:													75%
9.0 Application of Program to Site Model:													75%

Bibliography

Shalek, Kyle; “Electrical Property Investigation of Potential Carbon Sequestration Formations”. Oral Presentation at AAPG ACE Long Beach, CA, 2012. Abstract 1236840.

Murphy, Michael; “Pore Distribution in the Ordovician Shale of the Utica/Point Pleasant Sub-Basin”. Poster Presentation at AAPG ACE Long Beach, CA, 2012. Abstract 1241020.