Geologic Characterization of the South Georgia Rift Basin for Source Proximal CO_2 Storage

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Michael G. Waddell
Earth Sciences and Resources Institute
University of South Carolina

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National Energy Technology Laboratory
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Developing the Technologies and Building the Infrastructure for CO_2 Storage
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Presentation Outline

- Project goals and benefits
- Overview of the geology of the South Georgia Rift basin in SC
- Results of petrographic and core analysis from the Rizer #1
- Future investigations in the SGR
- Summary

Benefit to the Program

Program Goals:

- Develop technologies that will support industries' ability to predict CO_2 storage capacity in geologic formations to within ±30 percent.
- Develop technologies to demonstrate that 99 percent of injected CO_2 remains in the injection zones.
- Conduct field tests through 2030 to support the development of BMPs for site selection, characterization, site operations, and closure practices.

Benefits Statement:

Our research is evaluating the feasibility of CO_2 storage in the Jurassic/Triassic strata of the buried South Georgia Rift basin and providing all data and analyses associated with this evaluation to the NATCARB database. This is the first characterization effort in a relatively unexplored basin that may have tremendous potential for storing large quantities of CO_2.

Project Overview:
Goals and Objectives

Our project objectives address the fundamental program goal of site characterization of promising geologic formations for CO_2 storage. Specifically, characterization of the South Georgia Rift (SGR) basin is answering the following questions:

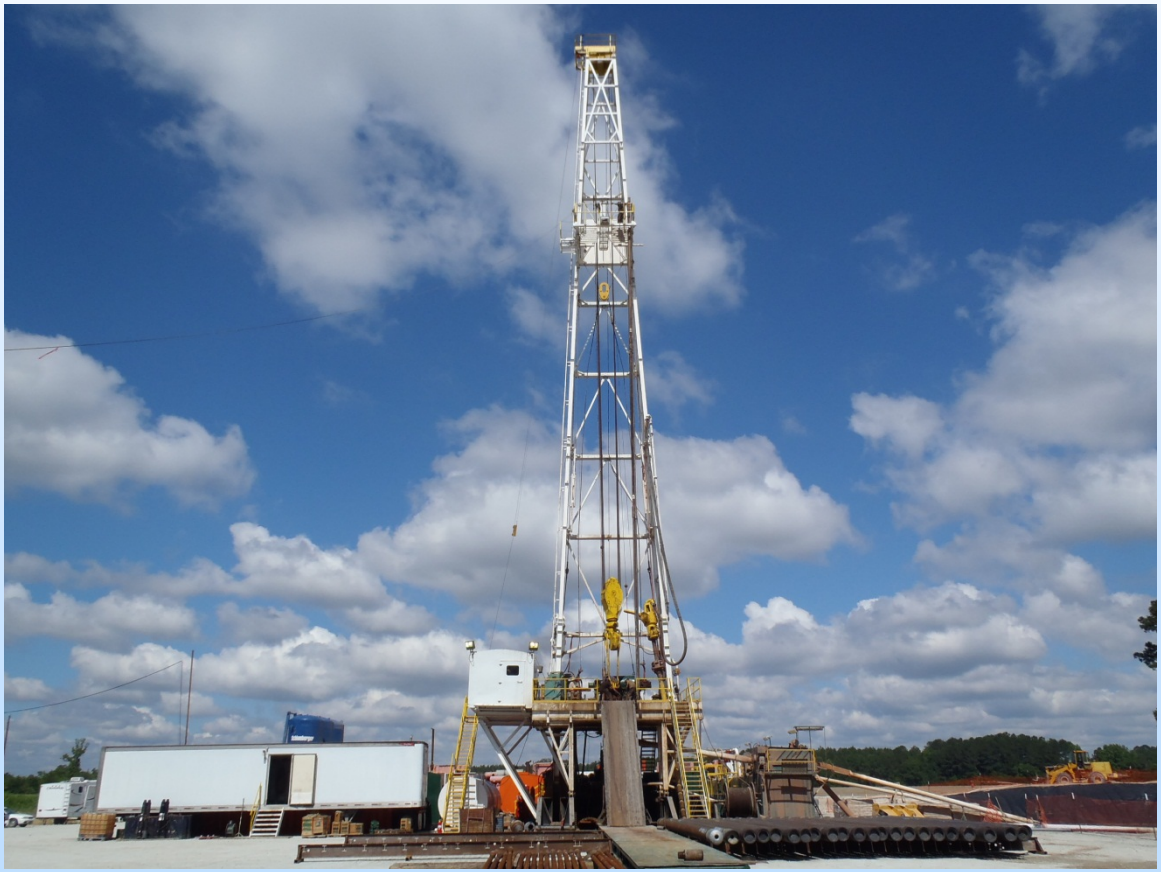
- Are there porous horizons with the potential to store at least 30M tonnes of CO_2
- Are the trapping reservoirs structurally competent enough to prevent injected CO_2 from migrating upward into the Coastal Plain aquifers

Success Criteria (activities completed):

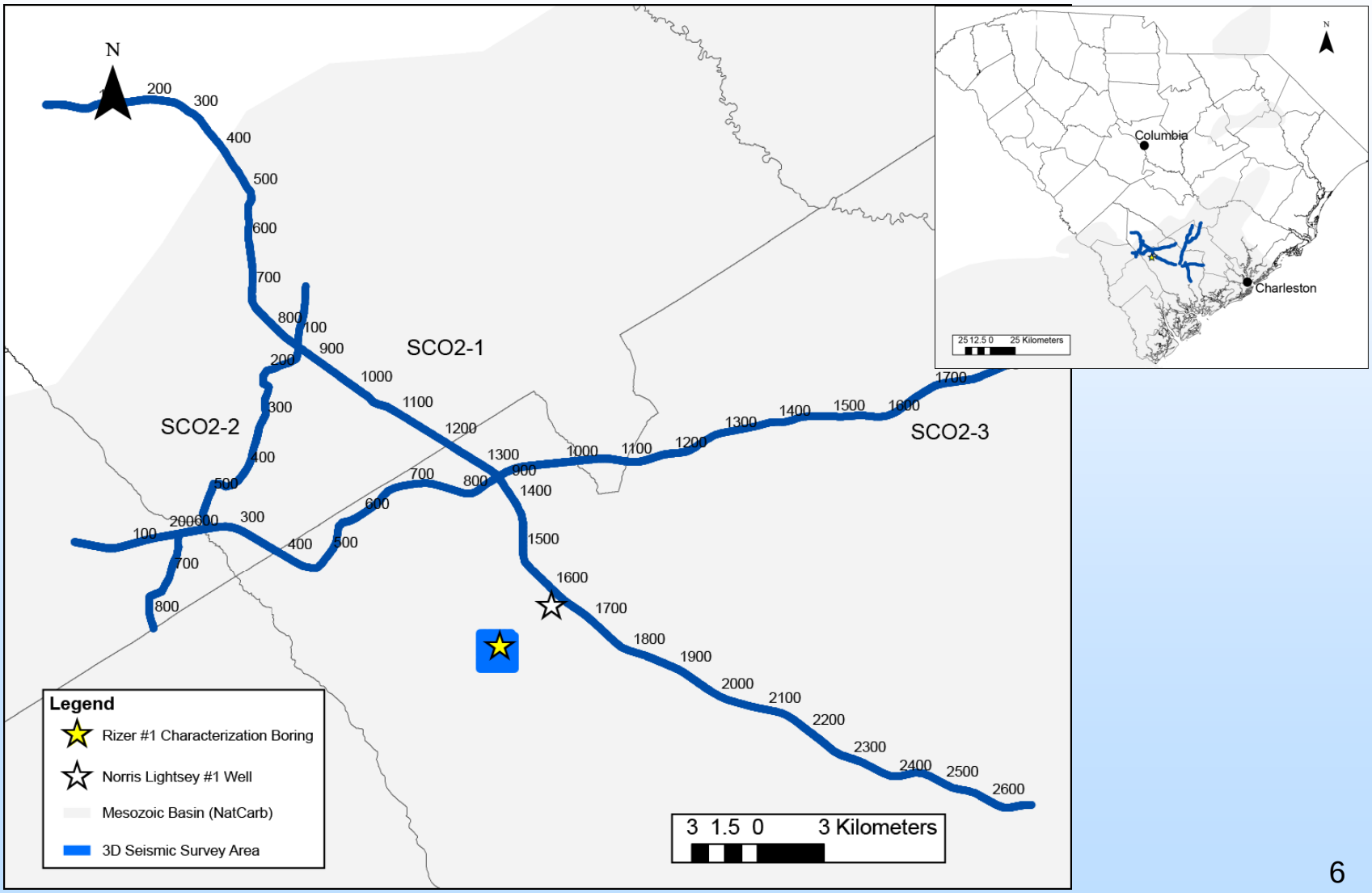
- Assimilation of existing data and information pertaining to SGR geology
- 240 km 2D reflection seismic acquired; 3D seismic acquired at test borehole site
- Characterization borehole drilled, cored, and logged
- 3D numerical simulation of CO_2 injection scenarios

Technical Status

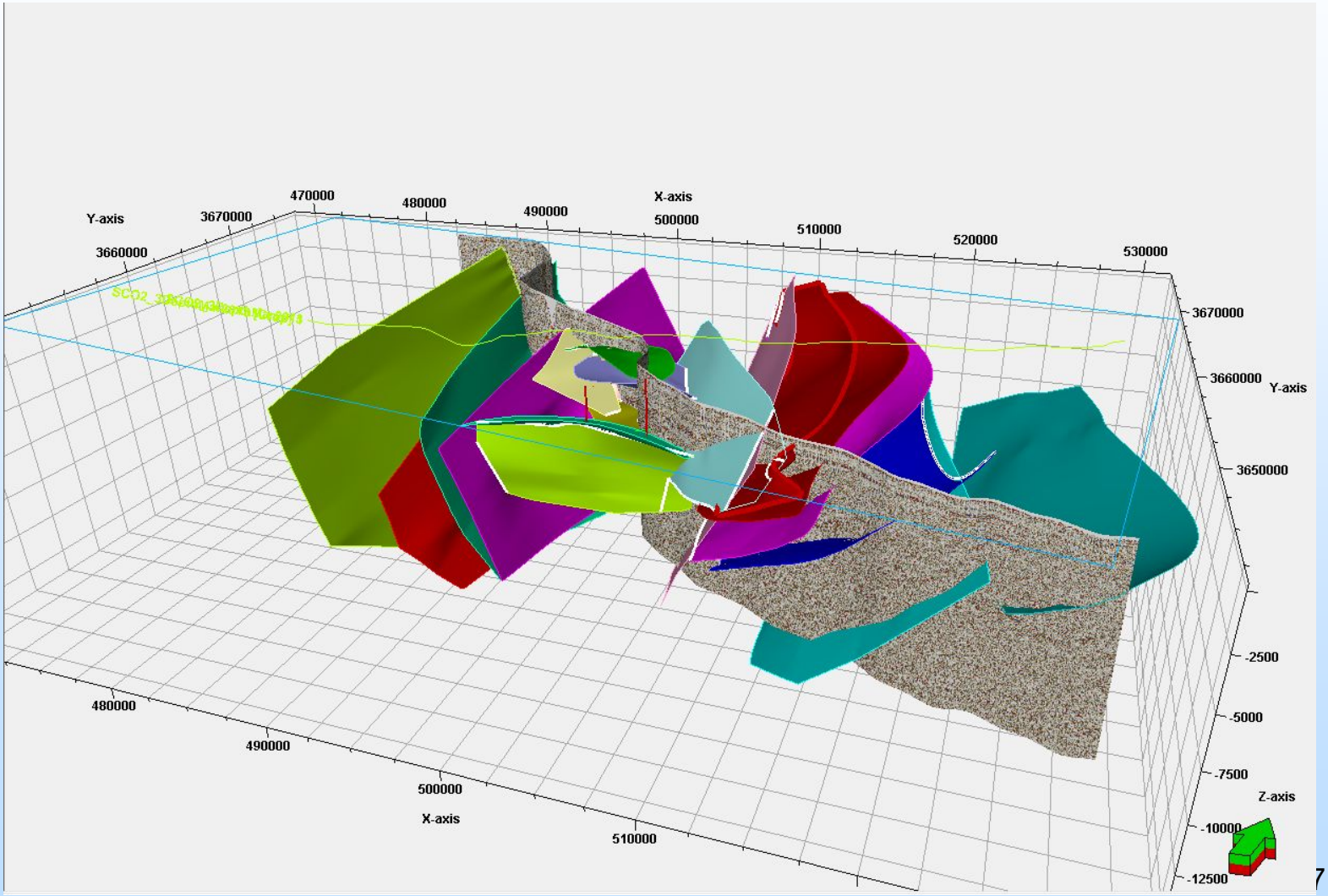
RIZER # 1 Test Boring



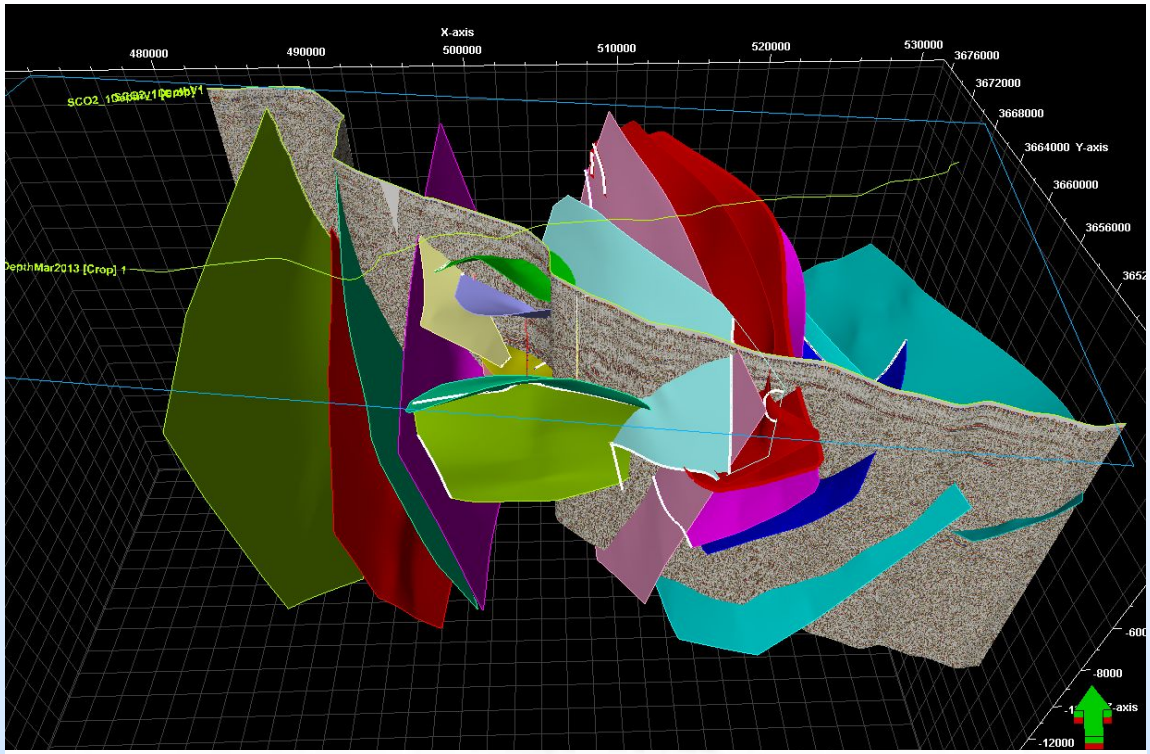
Seismic Lines



Fault Model


Y-axis
3660000
3670000
470000
480000
490000
X-axis
500000
510000
520000
530000
3670000
3660000
Y-axis
3650000
-2500
-5000
-7500
Z-axis
-10000
-12500
480000
490000
500000
X-axis
510000

Fault Model


X-axis
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490000
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3664000 Y-axis
3660000
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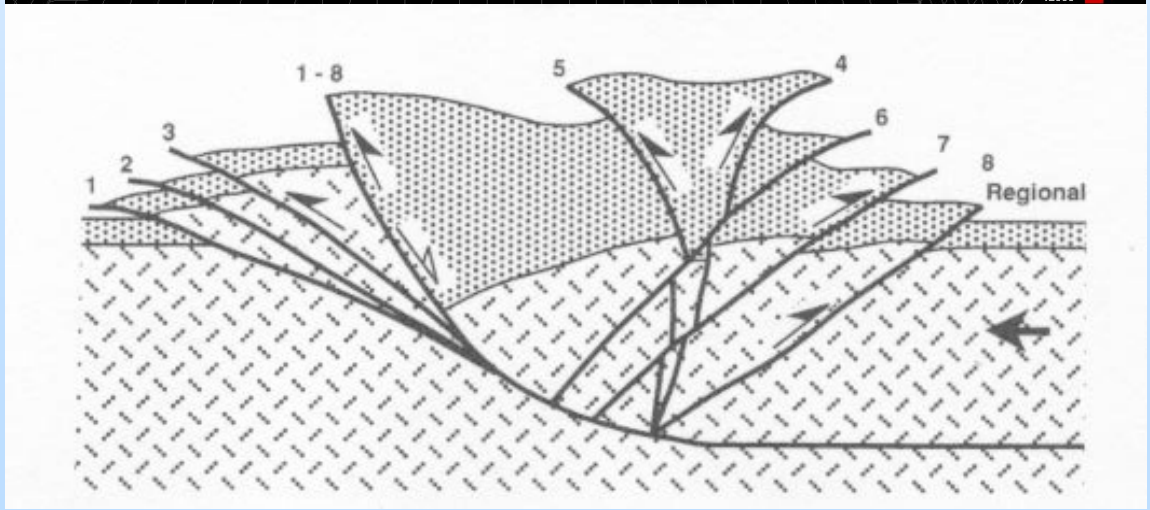
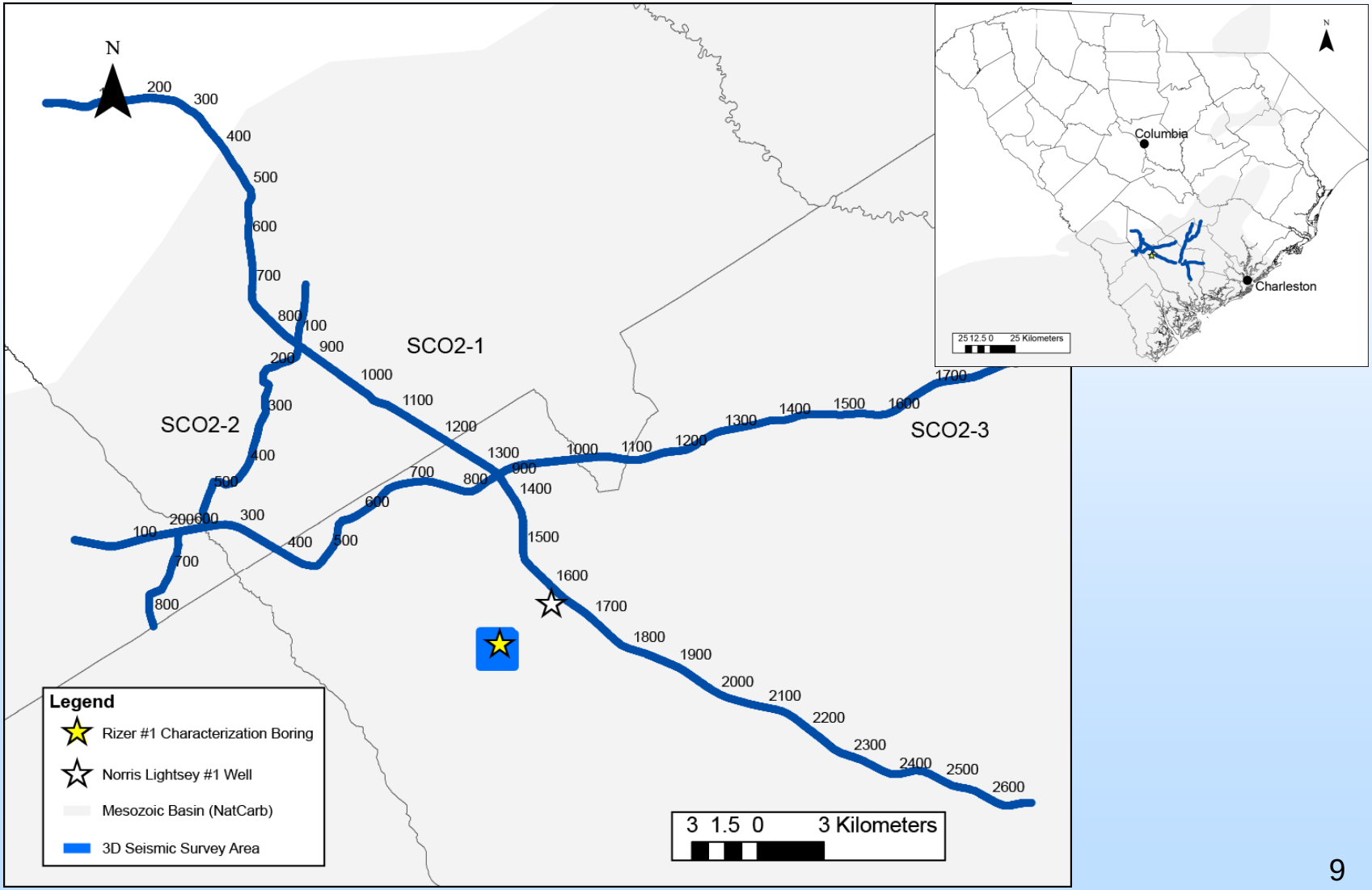
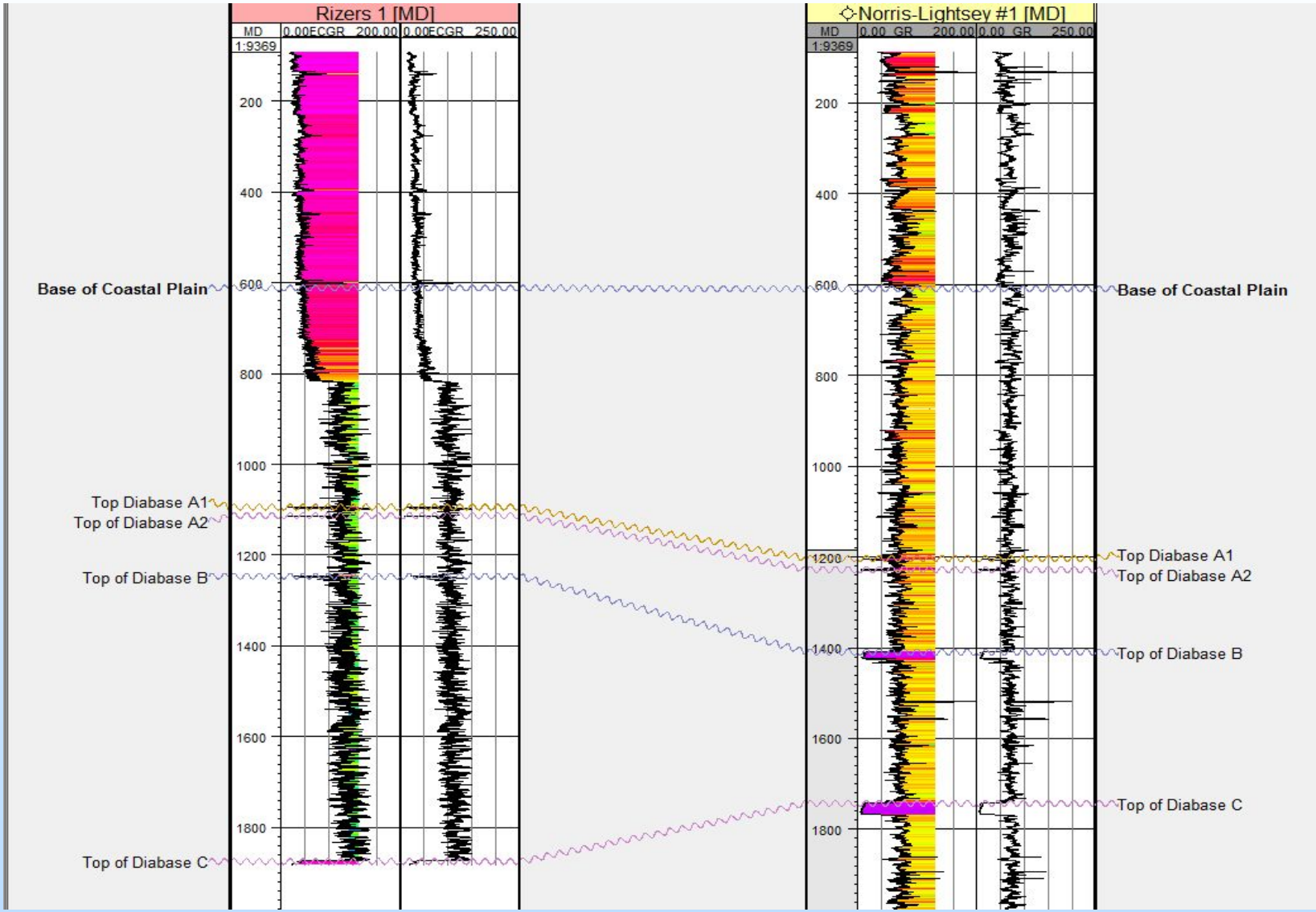
DepthMar2013 [Crop] 1
-8000
-12000


1 - 8
5
4
6
7
8
Regional
3
2
1

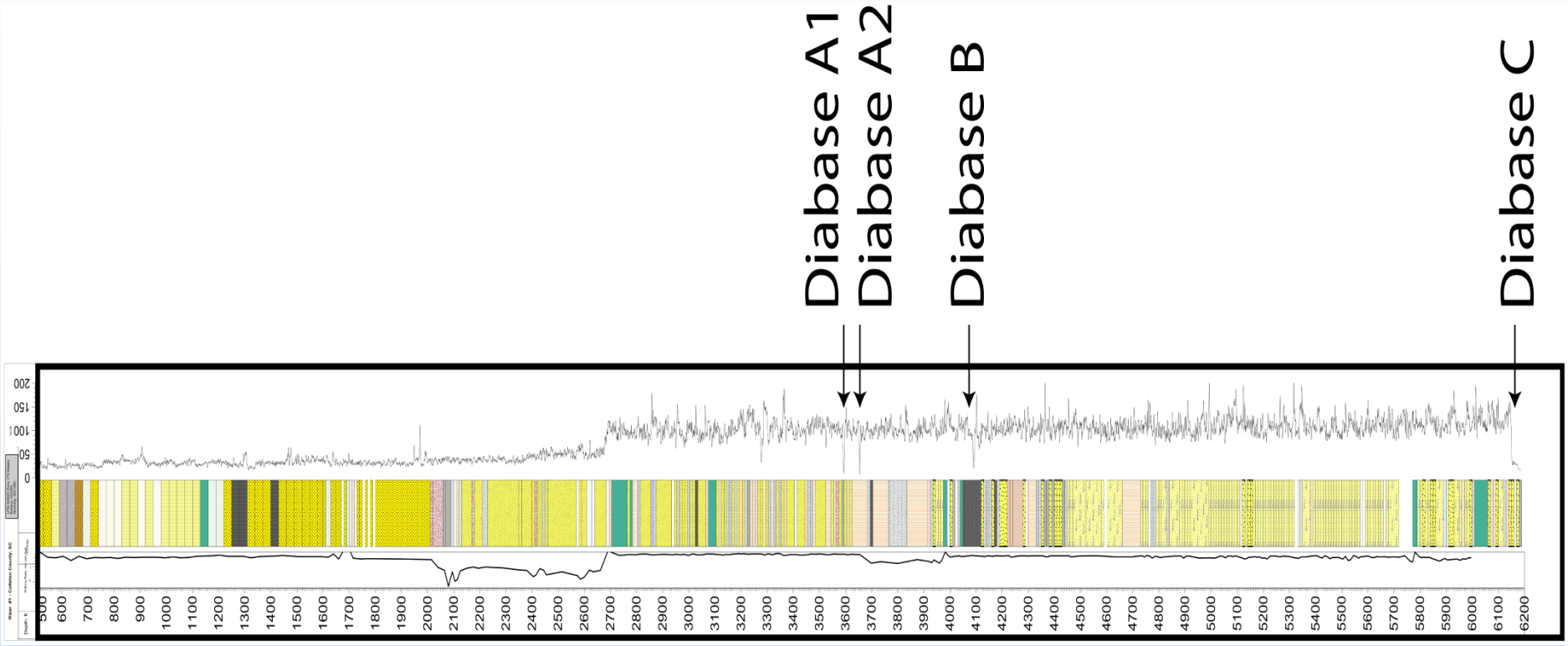
Well Location



Rizer #1 and Norris Lightsey #1

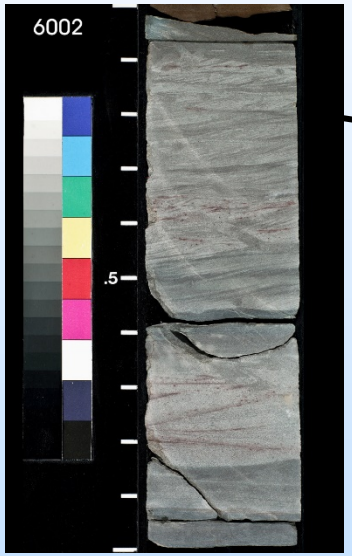


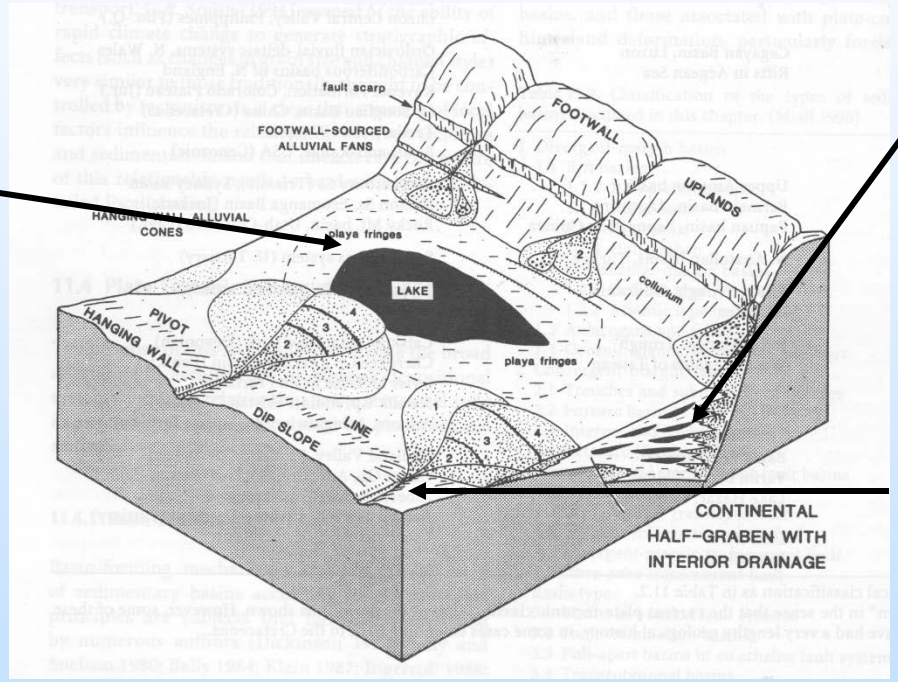
Rizer #1 Test Boring
TD 6200 Ft (1890 m)



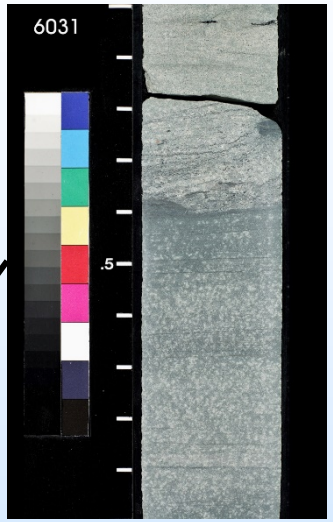
Half-graben with Interior Drainage

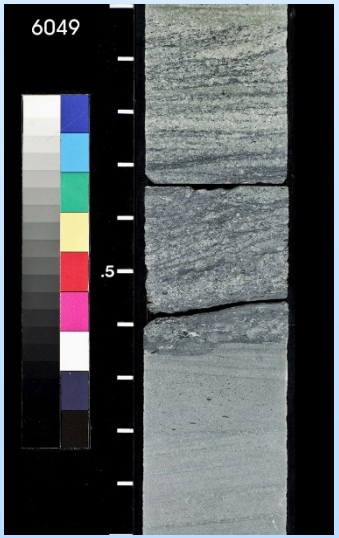
Saline Lacustrine





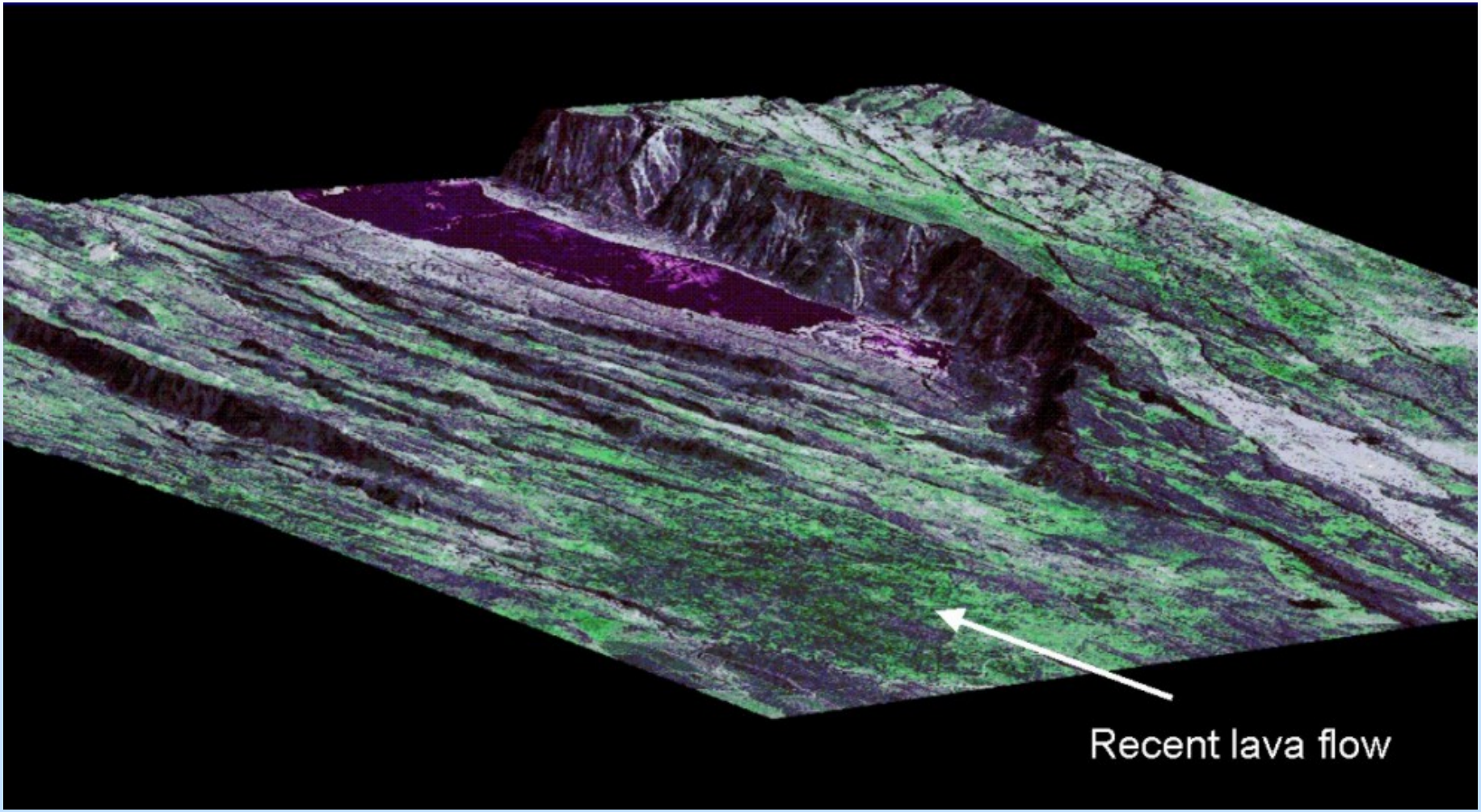
Stacked Overbank





Fluvial Channel

Modern East African Rift



Core Analysis
Whole Core

22 porosity and permeability measurements

Whole core analysis

Average Porosity (Horizontal)	3.1 %
Average Porosity (Vertical)	2.6 %
Average Permeability (Horizontal)	0.0049 md (air)
Average Permeability (Vertical)	0.0032 md (air)

Rotary Core Analysis

106 rotary core porosity and permeability measurements

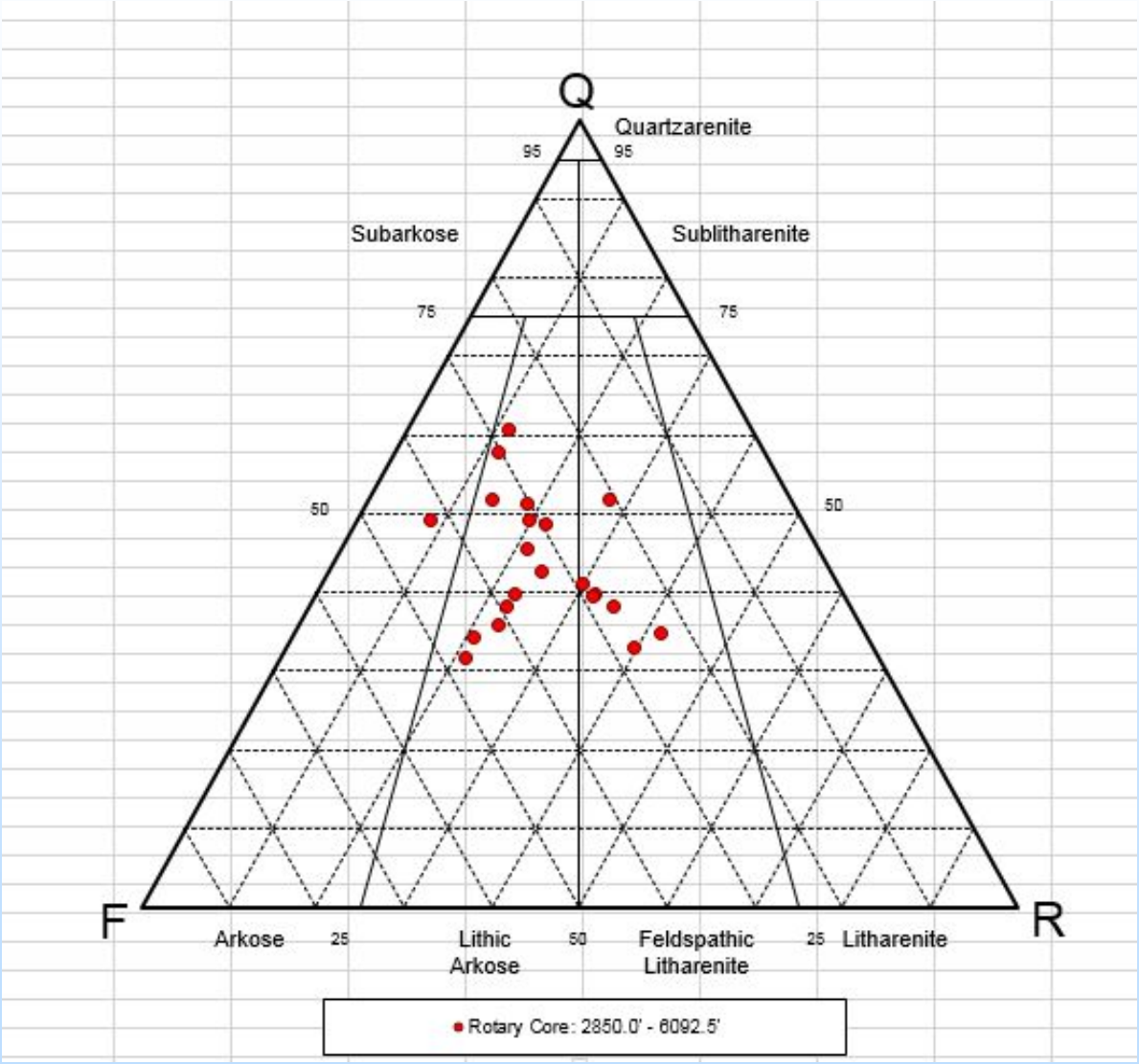
Rotary core analysis

- Average Porosity (Horizontal) 3.4%
- Average Permeability (Horizontal) 0.065 md (air)

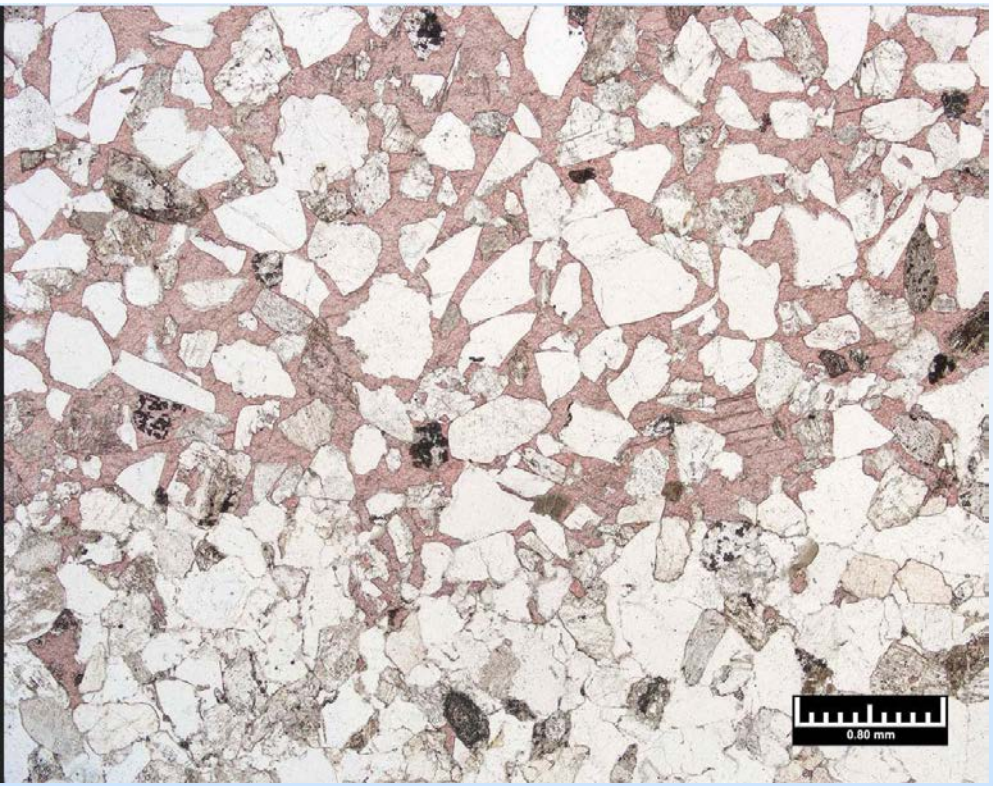
Petrographic Analysis

- 10 thin section analyses (whole core)
- 9 XRD analyses (whole core)
- 20 thin section analyses (rotary cores)
- 39 XRD analyses (rotary cores)

Ternary Plot
Rotary Cores

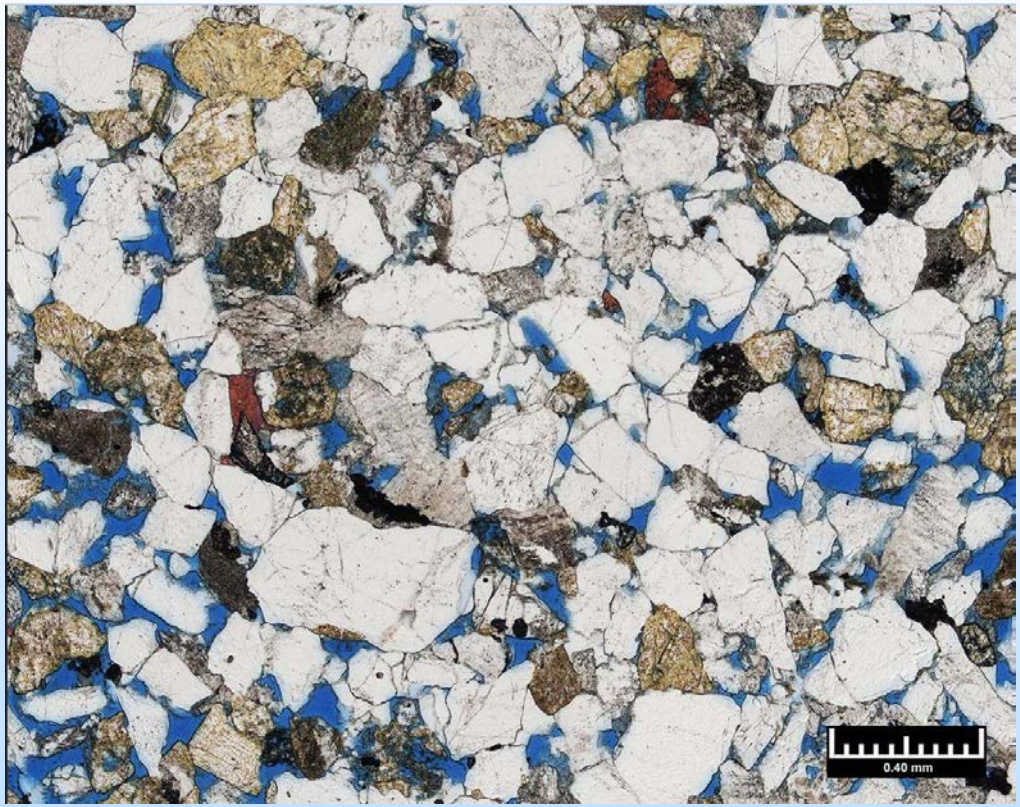


Depth 1,627 m



Porosity (Ambient)*:
1.6%
Permeability (to Air)*:
0.0062 mD
Grain Density*:
2.66 gm/cc
Lithology:
Lithic arkose
Medium-grained sandstone
Compaction:
Low/high (pressure solution)
Sorting:
Moderate - well/moderate
Framework Grains:
Major:
Monocrystalline quartz
Minor:
Plagioclase, metamorphic rock fragments, metaquartzite, potassium feldspar
Trace:
Micas, polycrystalline quartz, heavy minerals, sedimentary and volcanic rock fragments
Illite is lining (tangentially) most grains
Cement/Replacement:
Minor occurrence of quartz overgrowth cement; calcite cement and calcite replacement; plagioclase cement and replacement; sphene cement
Porosity Types:
Minor microporosity

Depth 1505 m

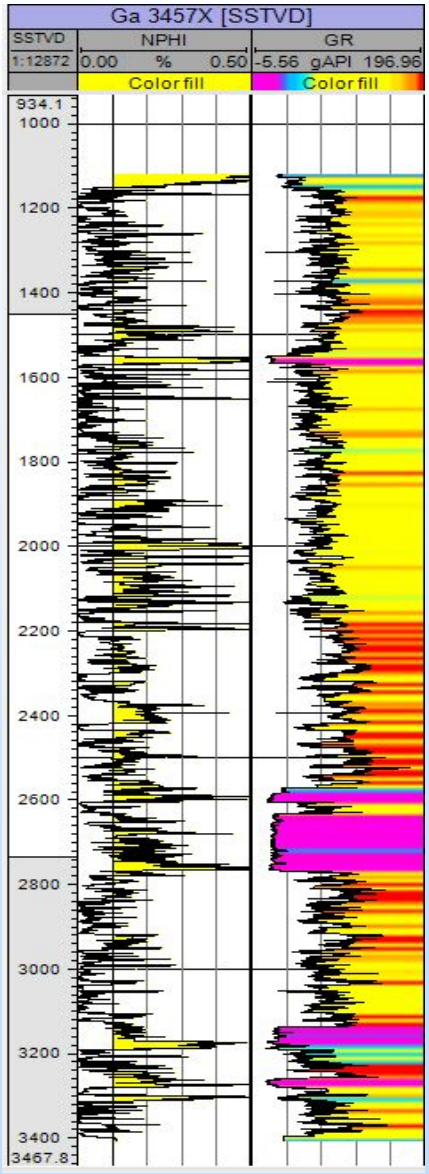


Porosity (Ambient)*:
12.4%
Permeability (to Air)*:
5.39 mD
Grain Density*:
2.67 gm/cc
Lithology:
Lithic arkose
Medium-grained sandstone
Compaction:
Moderate
Sorting:
Moderate
Framework Grains:
Major:
Monocrystalline quartz
Minor:
Potassium feldspar, plagioclase, metamorphic rock fragments, polycrystalline quartz, metaquartzite
Trace:
Heavy minerals, plutonic, volcanic, and sedimentary rock fragments, mica
Detrital Matrix:
None observed
Authigenic Clay:
Chlorite, fibrous illite, and kaolinite are coating grains and infilling pores
Cement/Replacement: Quartz overgrowth cement; calcite, potassium feldspar, sphene , and pyrite

Depth 1,114 m

GA 3457

142 m >10% Φ
Possible Reservior

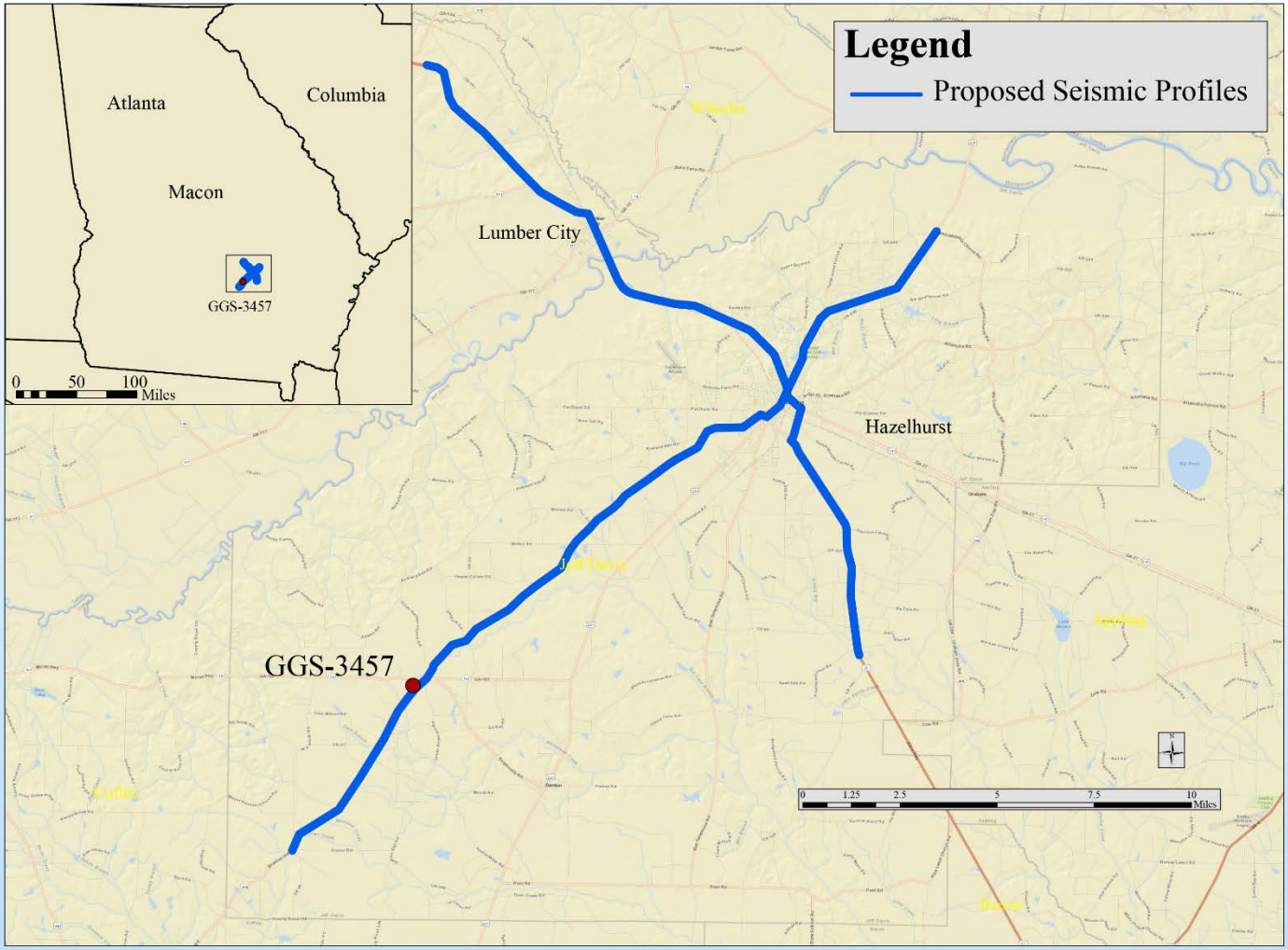


Base of Coastal Plain

Diabase

Diabase

GA Seismic Survey



Accomplishments to Date

- Site characterization field investigations completed
  - 240 km 2D seismic acquired
  - 3D seismic acquired over characterization borehole site
  - Characterization borehole drilled, cored, and wireline logged
- Completed Petrographic Analysis on 106 rotary sidewall cores, and 18.3 m whole core
  - Detailed compaction and burial history study almost completed
  - Detailed integration of geologic information completed and preliminary 3D geologic model developed
  - Reprocessing seismic lines SCO2 series almost completed
  - Completion of the 1000 year injection simulation model

Summary

Key Findings

- SGR still appears to be capable of storing large quantities of CO_2 in compartmentalized, stacked storage reservoirs
- It appears (very limited data) that the some of the SGR sub basins in lower SC have gone through a complex structural history which has limited the amount of reservoir for CO_2 storage.
- There appears to be favorable reservoirs for CO_2 storage in areas that do not have a complex structural history such as the southern part of the SGR
- In some of the SGR sub basins there is the possibility of using the diabase as reservoir and fine-grained clastic sediments as caprock.
- SGR is a composite basin as defined by Schlishce, 2003

Lessons Learned

- Geologic characterization in a “frontier” area has many logistic and scientific challenges not encountered in well-studied areas
  - Lack of data
  - Land access
  - Uncertainty/risk associated with field characterization
  - Lack of industry exploration in the area

Future Plans

- Conduct farther research in the southern part of the South Georgia Rift Basin
- Farther investigate the possibility of using the diabase intrusions as possible reservoir

DOE/NETL Acknowledgment:

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DOE/NETL Disclaimer:

Appendix

Organization Chart

University of South Carolina — SCHOOL OF EARTH, OCEAN & ENVIRONMENT — EARTH SCIENCES AND RESOURCES INSTITUTE → Lead organization – project mgmt., geologic characterization, injection simulation

COLLEGE OF ARTS AND SCIENCES — EARTH AND OCEAN SCIENCES → Geologic overview of SGR

SCDNR SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES — SCGS SOUTH CAROLINA GEOLOGICAL SURVEY → Geologic interpretation, field support, core repository

ILLINOIS STATE GEOLOGICAL SURVEY → Project mgmt. support, review of findings

Bay Geophysical, Inc. → 2D and 3D seismic acquisition

Weatherford® LABORATORIES → Routine core analysis, special core analysis

Schlumberger Carbon Services → Characterization borehole mgmt., drilling, coring, wireline logging