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

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Infrastructure for CCS
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Presentation Outline

- Project goals and benefits
- Overview of the geology of the South Georgia Rift basin in SC and GA
- Results of petrographic and core analysis from the Rizer #1
- Preliminary Geologic Model of SC
- Overview of the Seismic Data from the southern portion of 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 BPMs 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 30 M tonnes of CO_2
- Are the trapping reservoirs structurally competent enough to prevent injected CO_2 from migrating upward into the Coastal Plain aquifers
- Are the physical and chemical properties of the possible porous horizons conducive for CO_2 injection and long-term storage

Success Criteria (activities completed):

- Assimilation of existing data and information pertaining to SGR geology
- 325 km 2D reflection seismic acquired in SC and GA; 3D seismic acquired at test borehole site
- Characterization borehole drilled, cored, and logged

Accomplishments to Date

- Site characterization field investigations completed
  - 240 km 2D seismic acquired in SC
  - 85 km 2D seismic acquired in GA
  - 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 completed
  - Detailed integration of geologic information completed and preliminary 3D geologic model completed
  - Reprocessing seismic lines SCO2 series completed
  - Acquired and process 85 km of additional seismic in the southern portion of the SGR

Technical Status

Petrographic Analysis

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

Core Analysis

22 whole core 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)

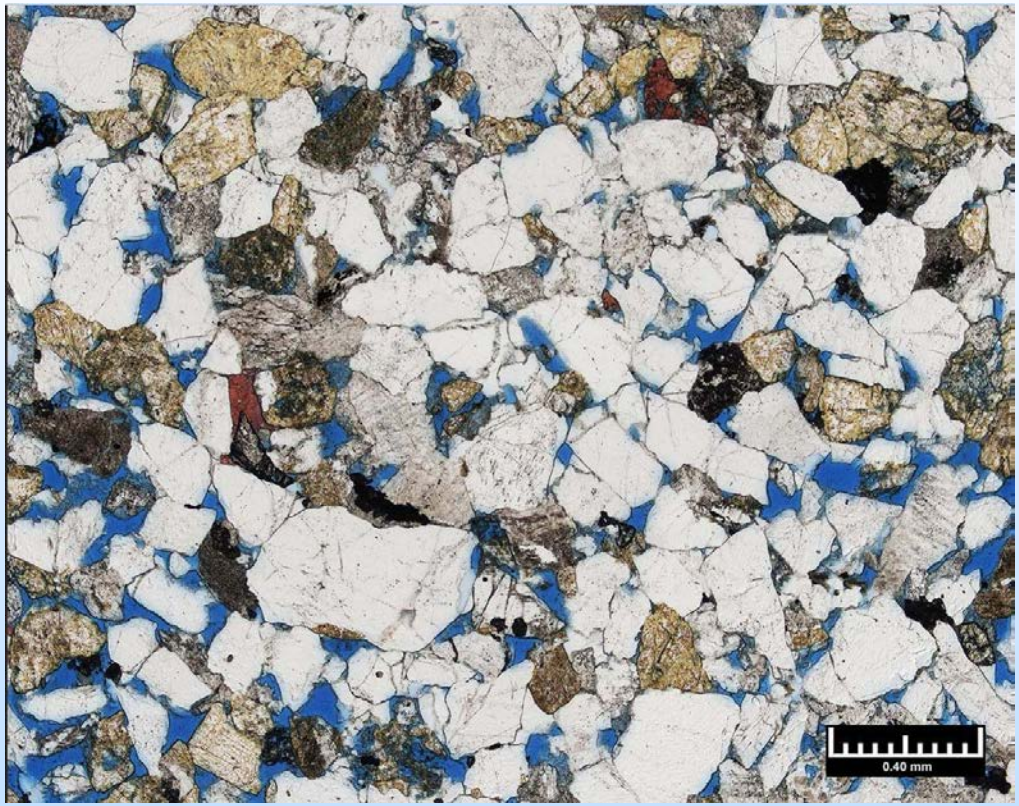
Core Analysis

106 rotary core porosity and permeability measurements

Rotary core analysis

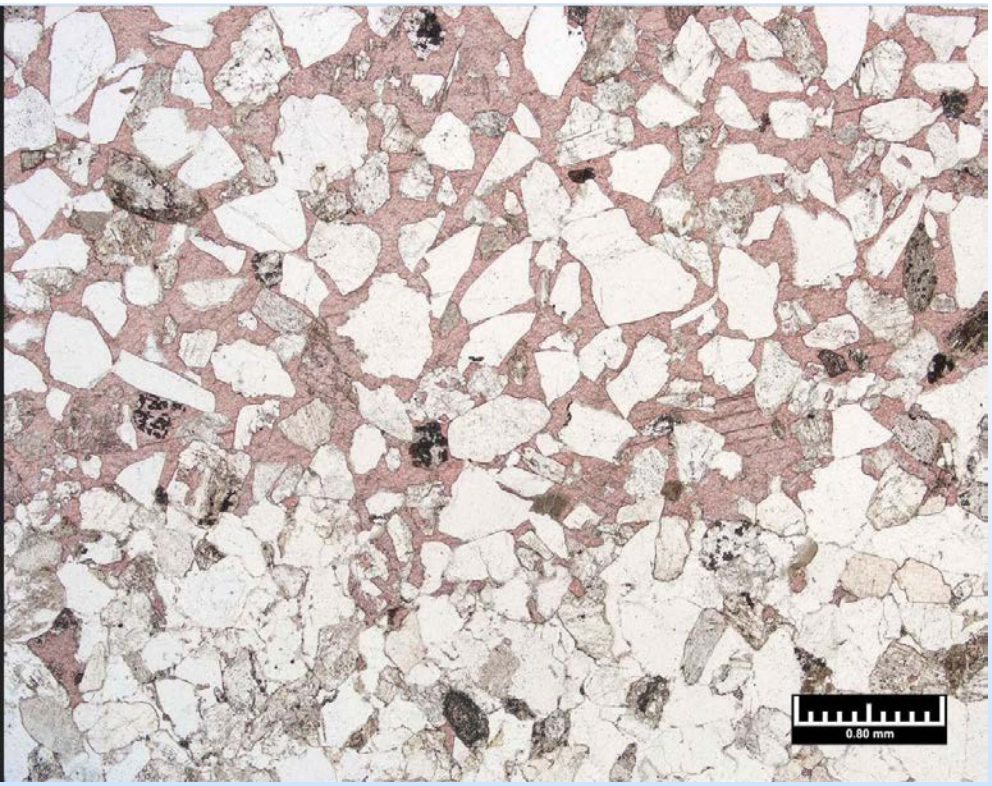
- Average Porosity (Horizontal) 3.4%
- Average Permeability (Horizontal) 0.065 md (air)

Depth 1505 m

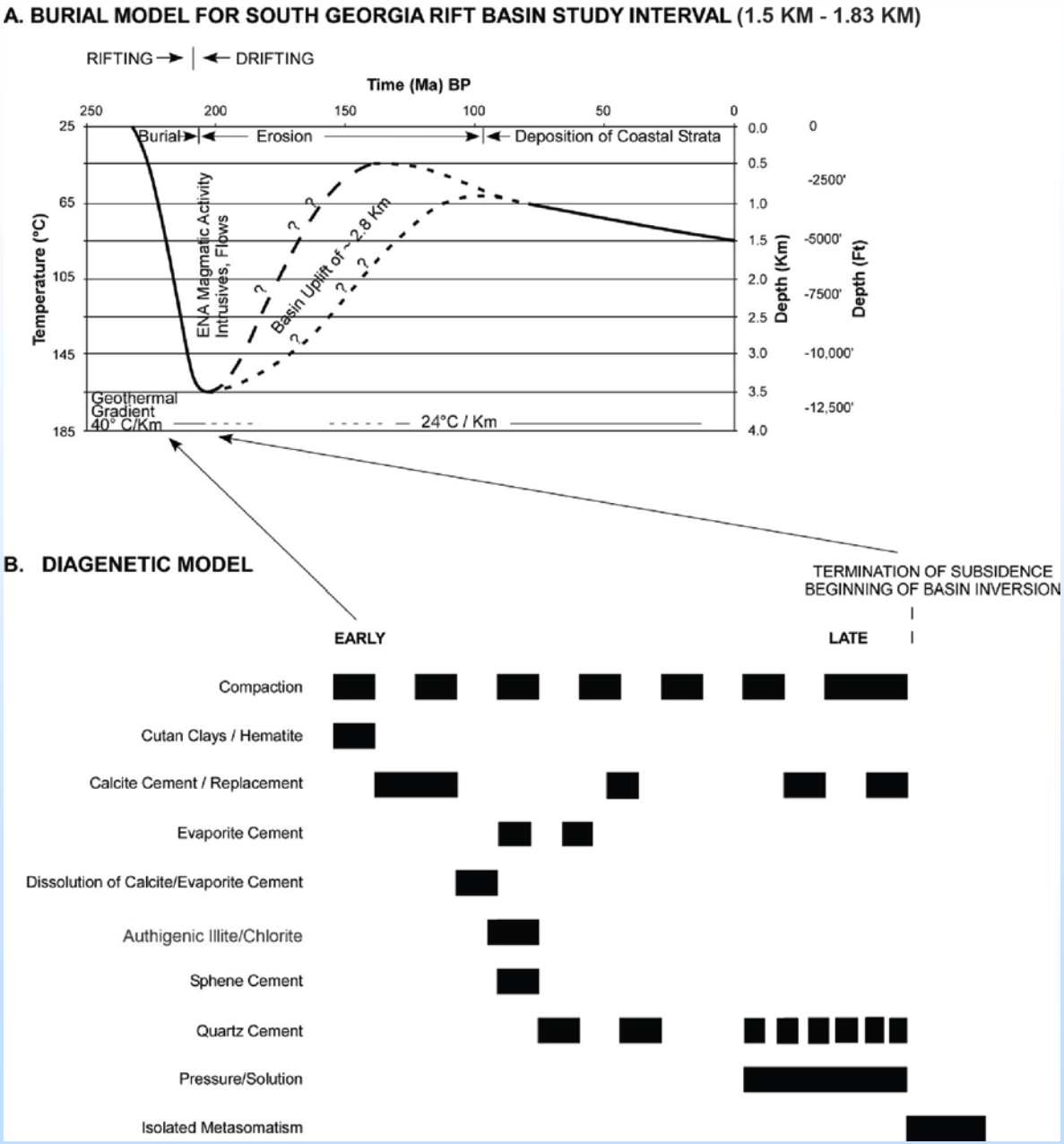


Porosity (Ambient)*:
12.4%
Permeability (to Air)*:
5.39 mD
Grain Density*:
2.67 gm/cc
Lithology:
Lithic arkose
Medium-grained sandstone
Compaction:
Moderate
Sorting:
Moderate
Framework Grains:
Major:
Monocrystalline quartz
Minor:
Potassium feldspar, plagioclase, metamorphic rock fragments, polycrystalline 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 1,627 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



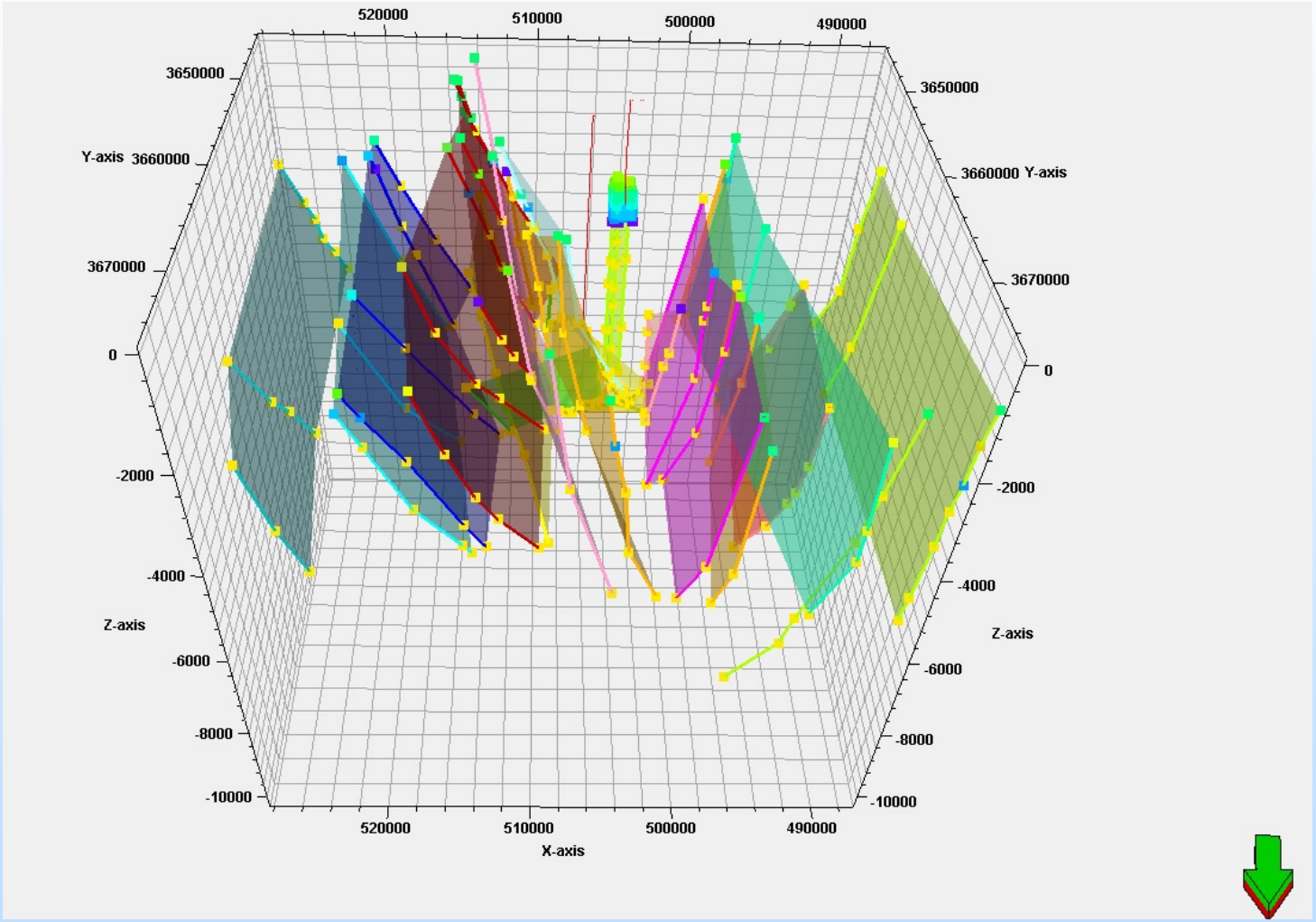
Secondary ion mass spectrometry (SIMS)

Isotope study of Rizer #1 quartz Cements indicates the cement with the lowest δ^{18} O formed at a pore water temperature of 183 ^{o}C at burial depths of approximately 3.96 km; or approximately 2.22 km Deeper than present burial depths.

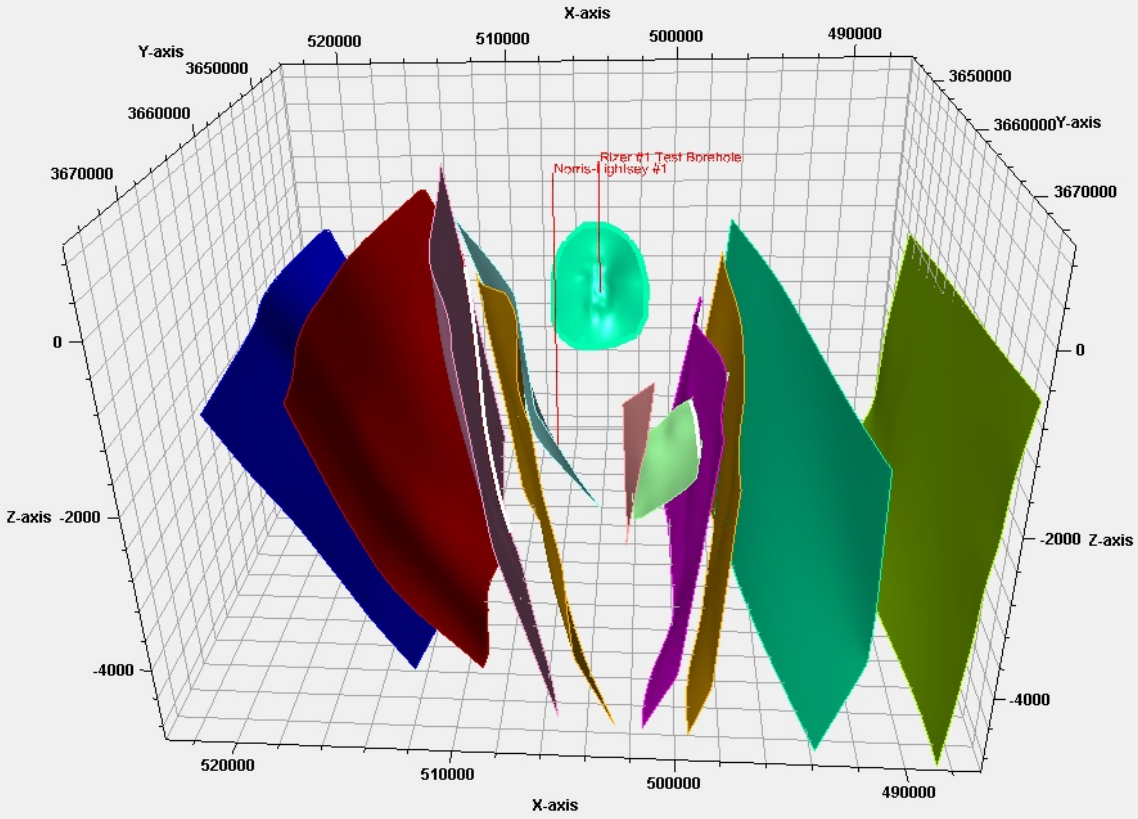
Approximately 0.70 km currently overlies the model Interval 1.52 km, this indicates 2.8 km of Triassic section was eroded prior to deposition of the younger coastal plain strata.

SC Geologic Model

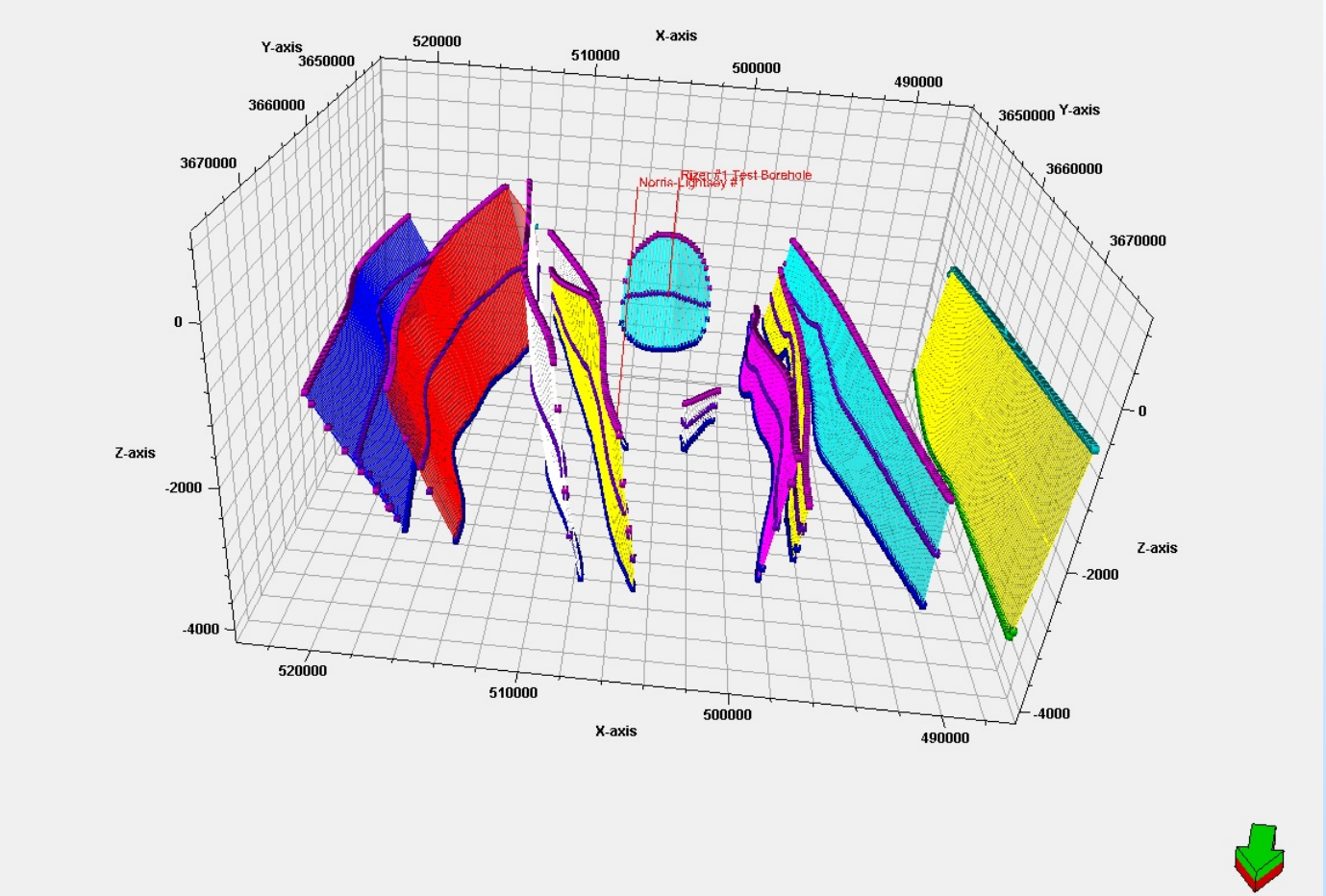
SC Fault Interpretations



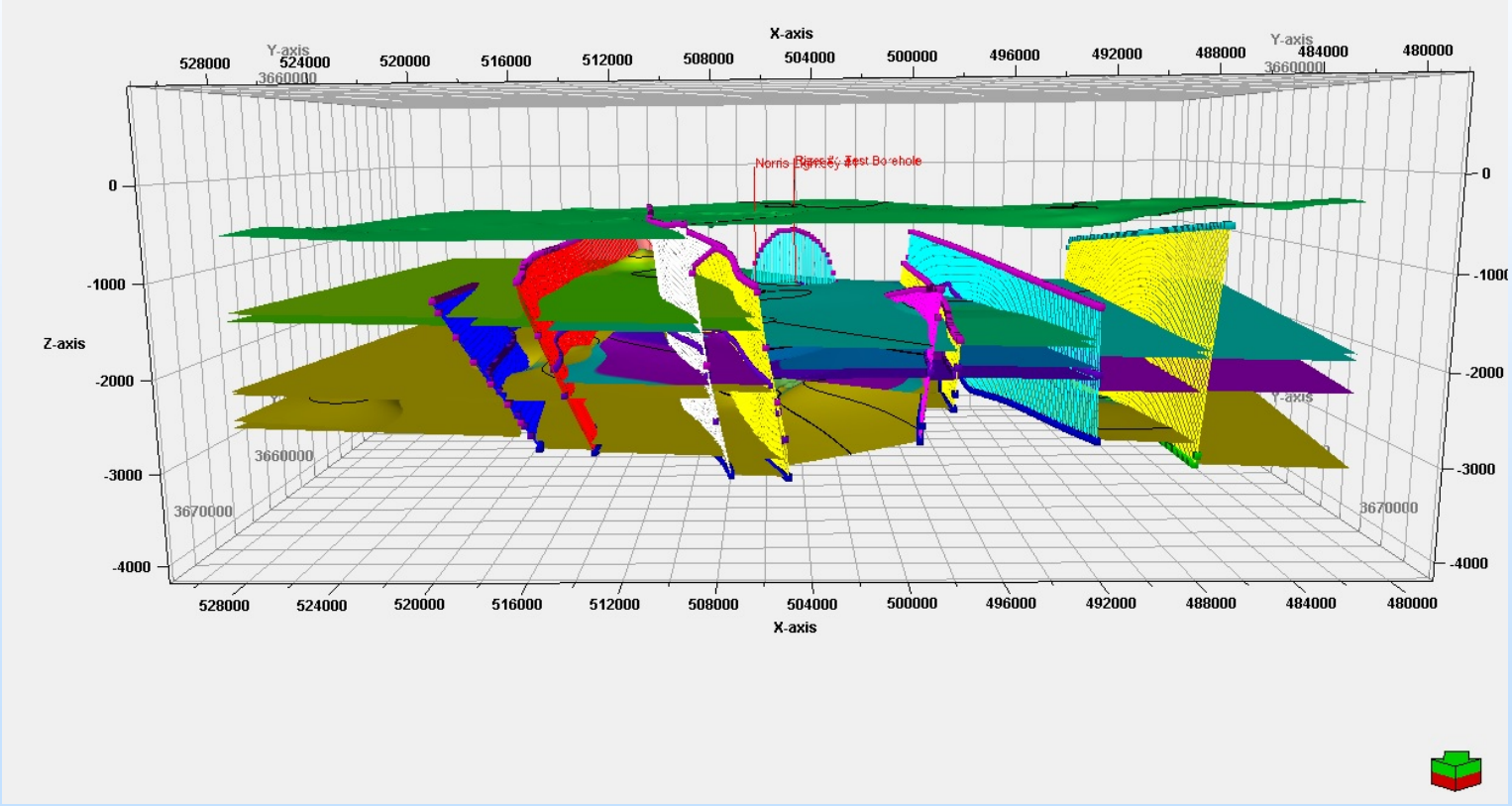
SC Fault Model



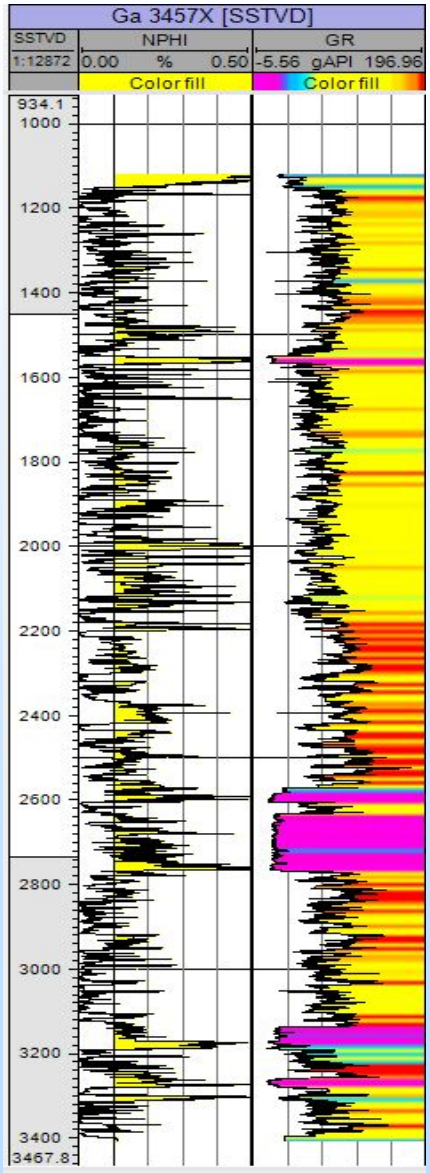
SC Fault Pillar Gridding



SC Fault and Horizon Pillar Grid



GA 3457

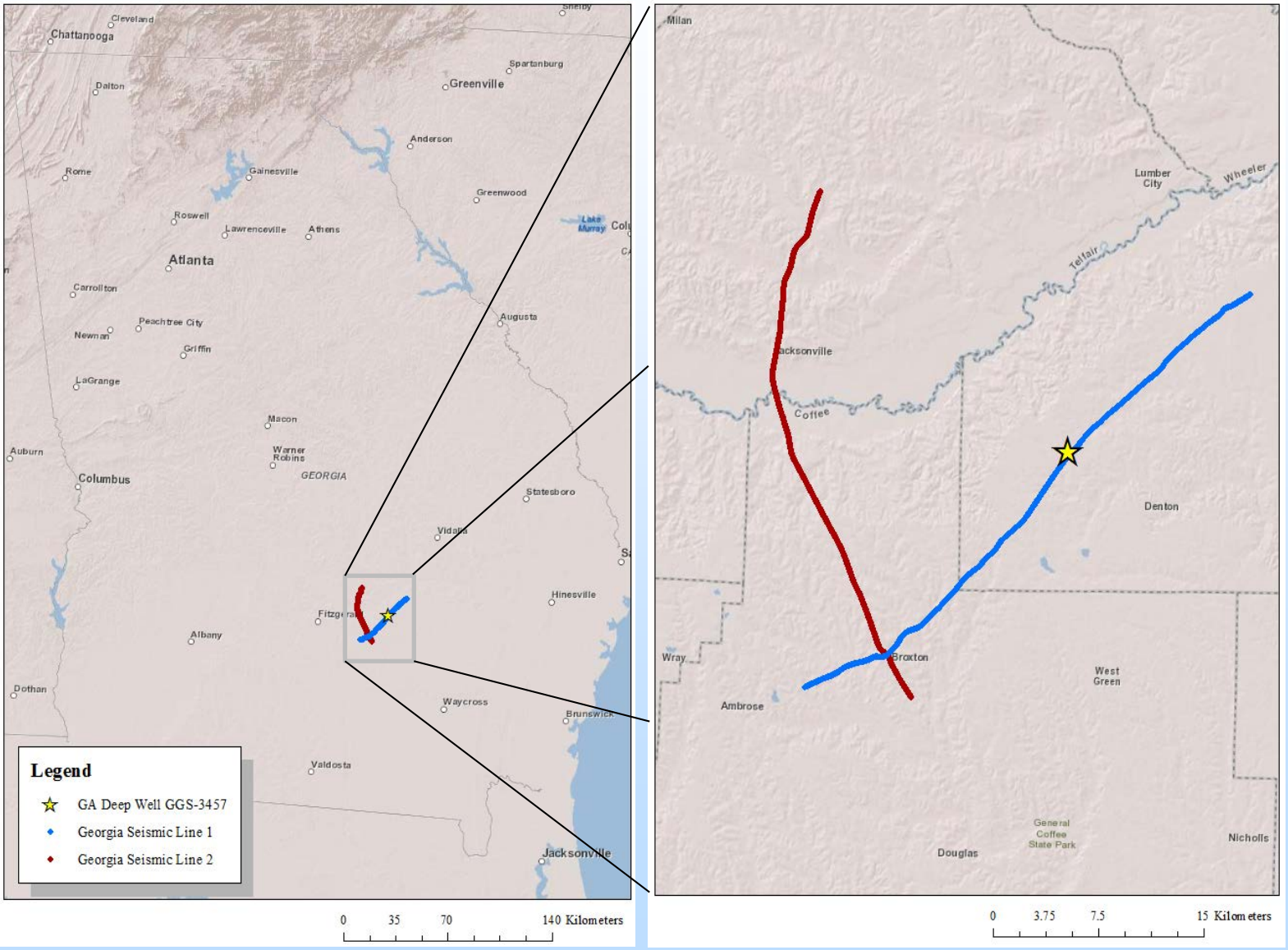


Base of Coastal Plain

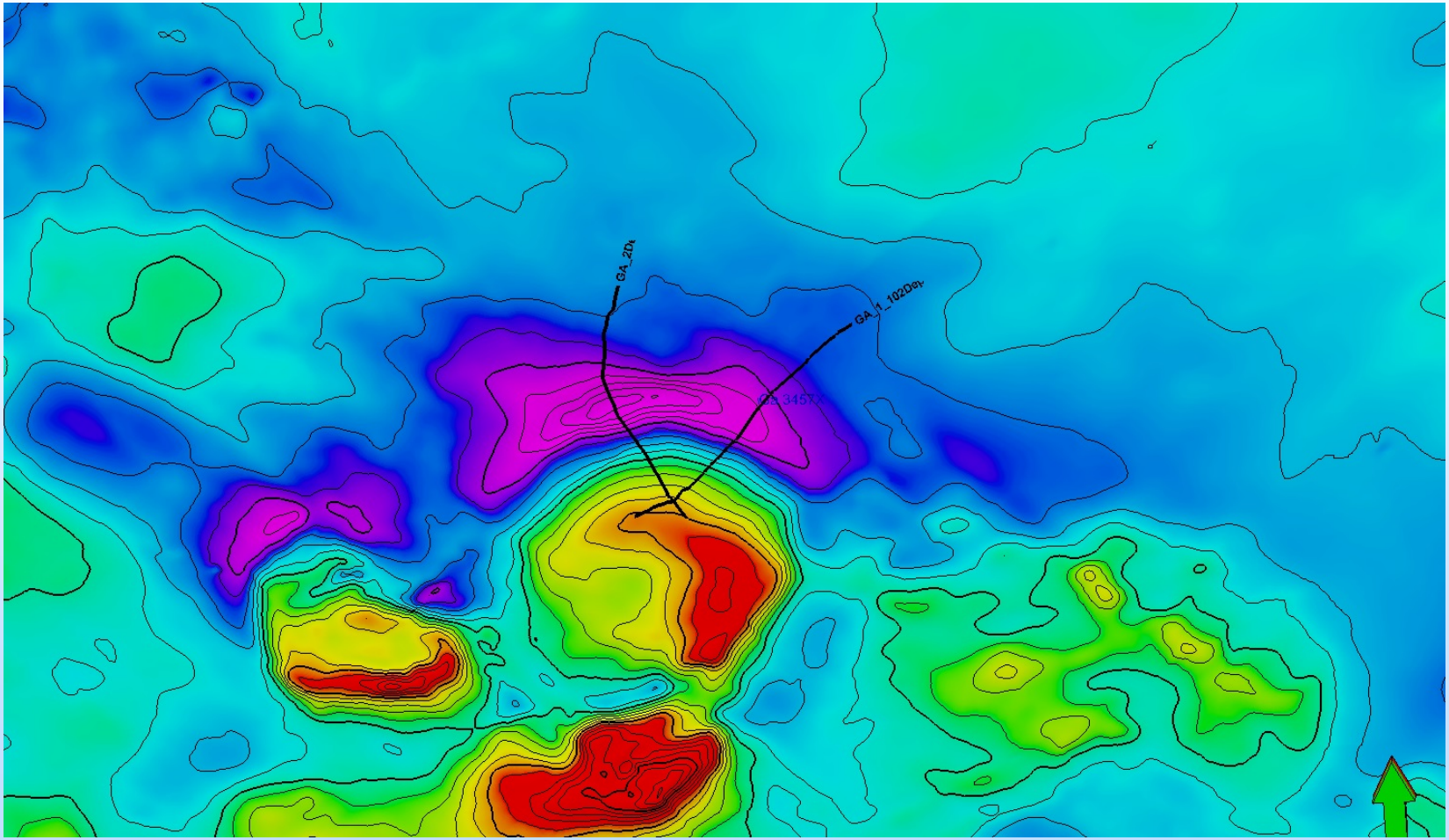
Diabase

Diabase

GA Seismic Survey



Aero Magnetic

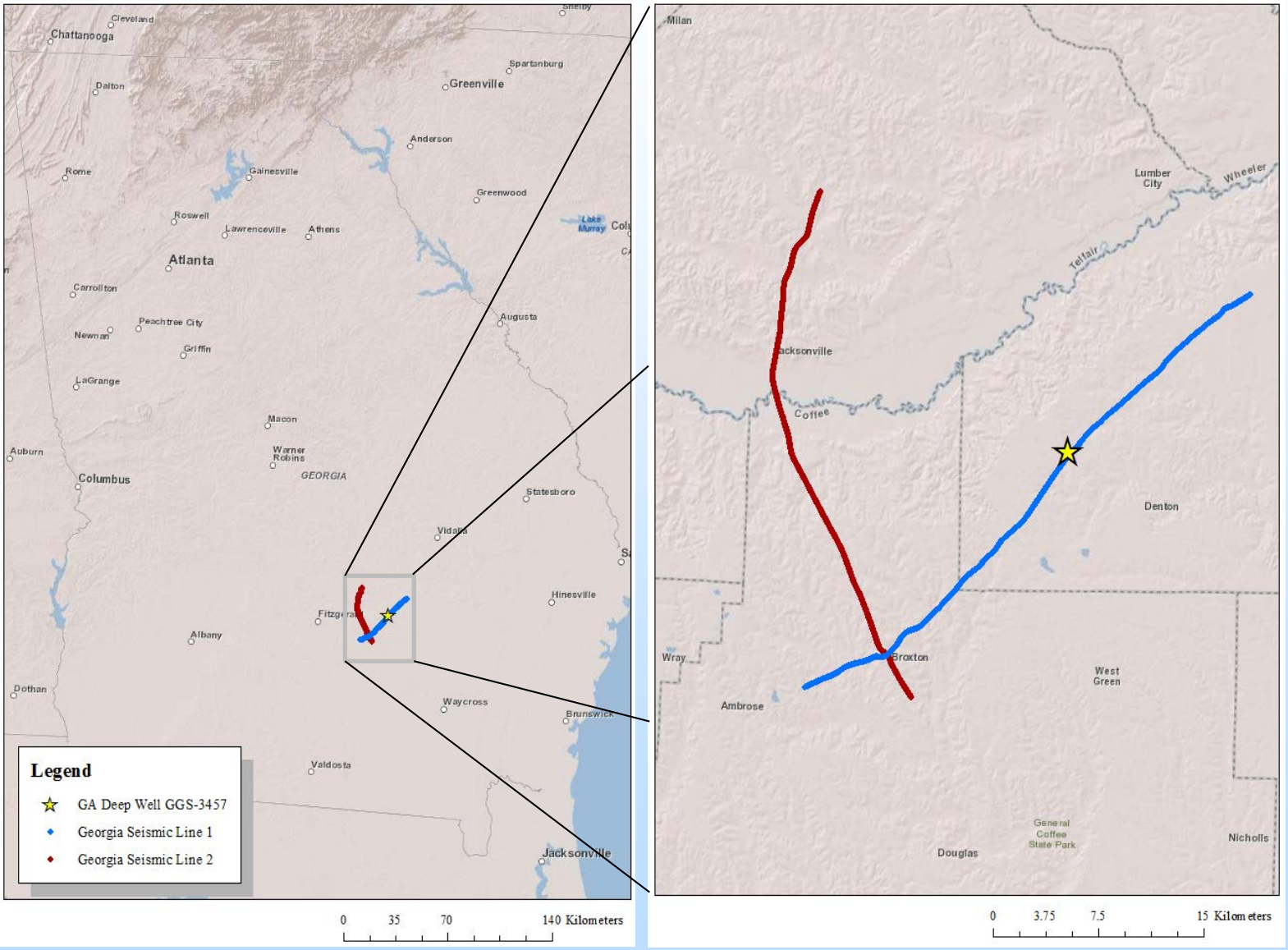


GA Acquisition

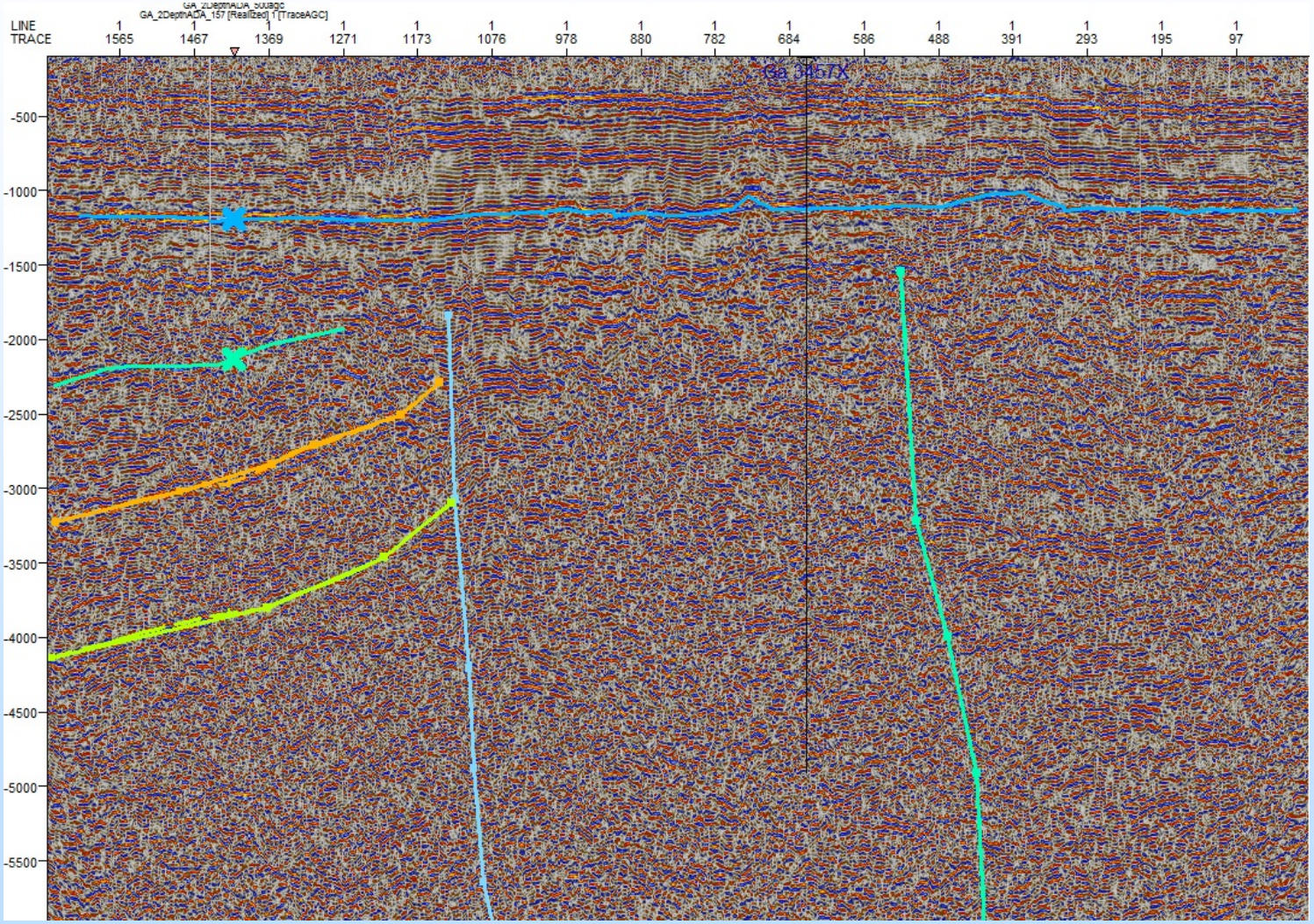
- Geophone spacing 52 m
- Geophone frequency 10 HZ
- Shot spacing 52 m
- Two vibrators sweep from 8 Hz to 70 Hz, 8 stacks per location
- Linear sweeps
- Sweep length 8 secs
- Record length 6 secs
- Sample rate 2 ms

Seismic Acquisition

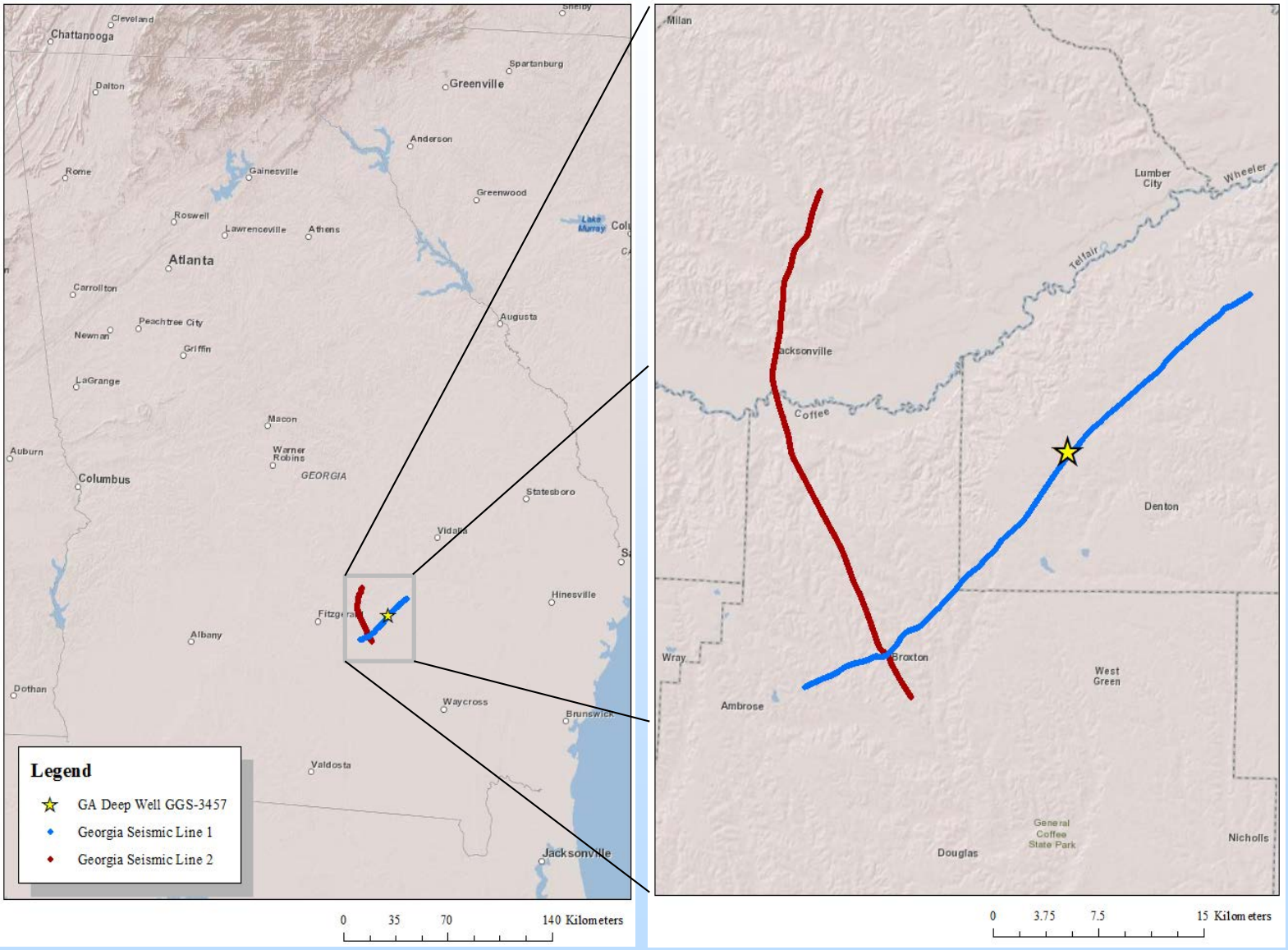
GA Seismic Survey



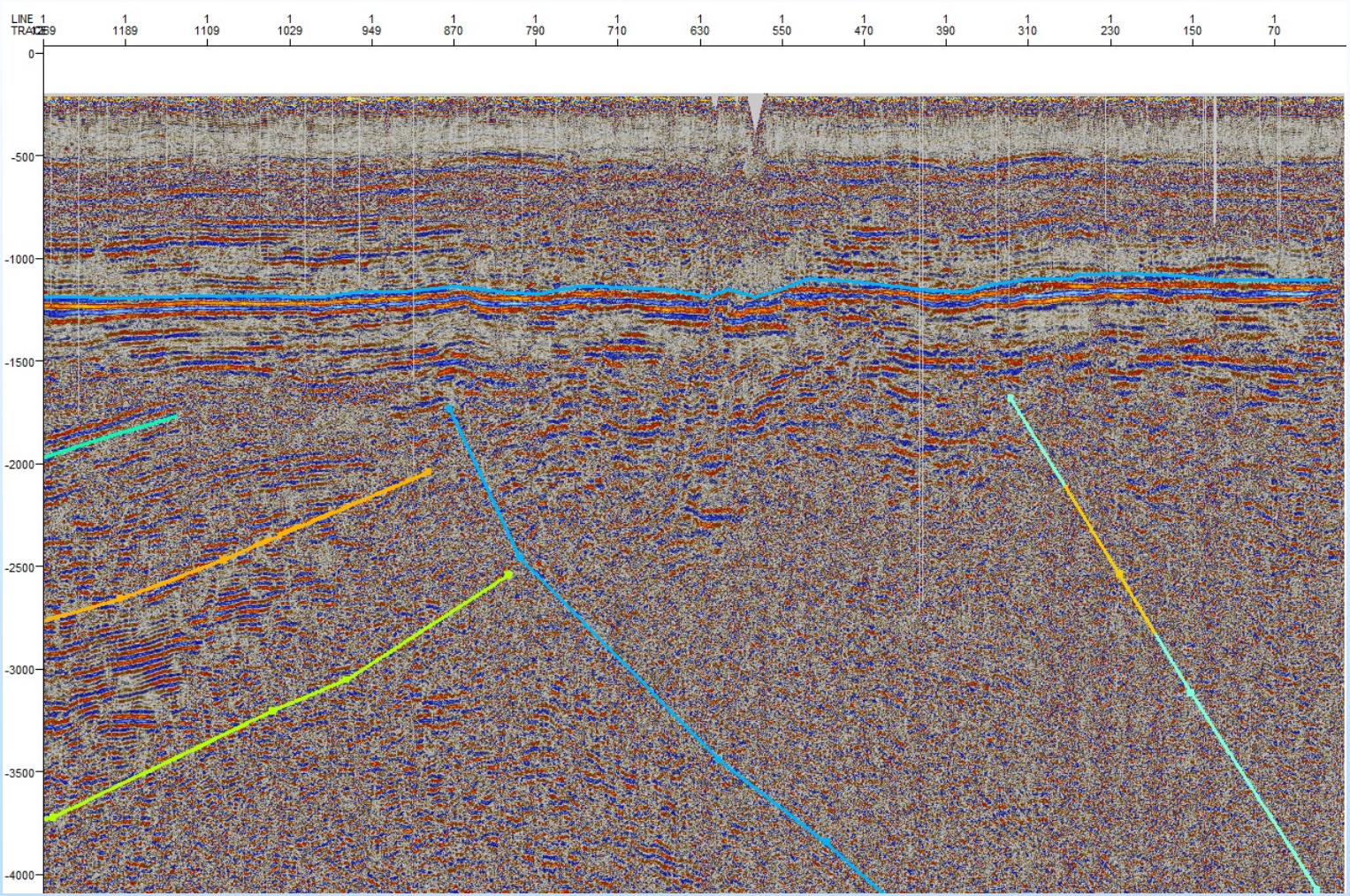
Seismic Line GA-1



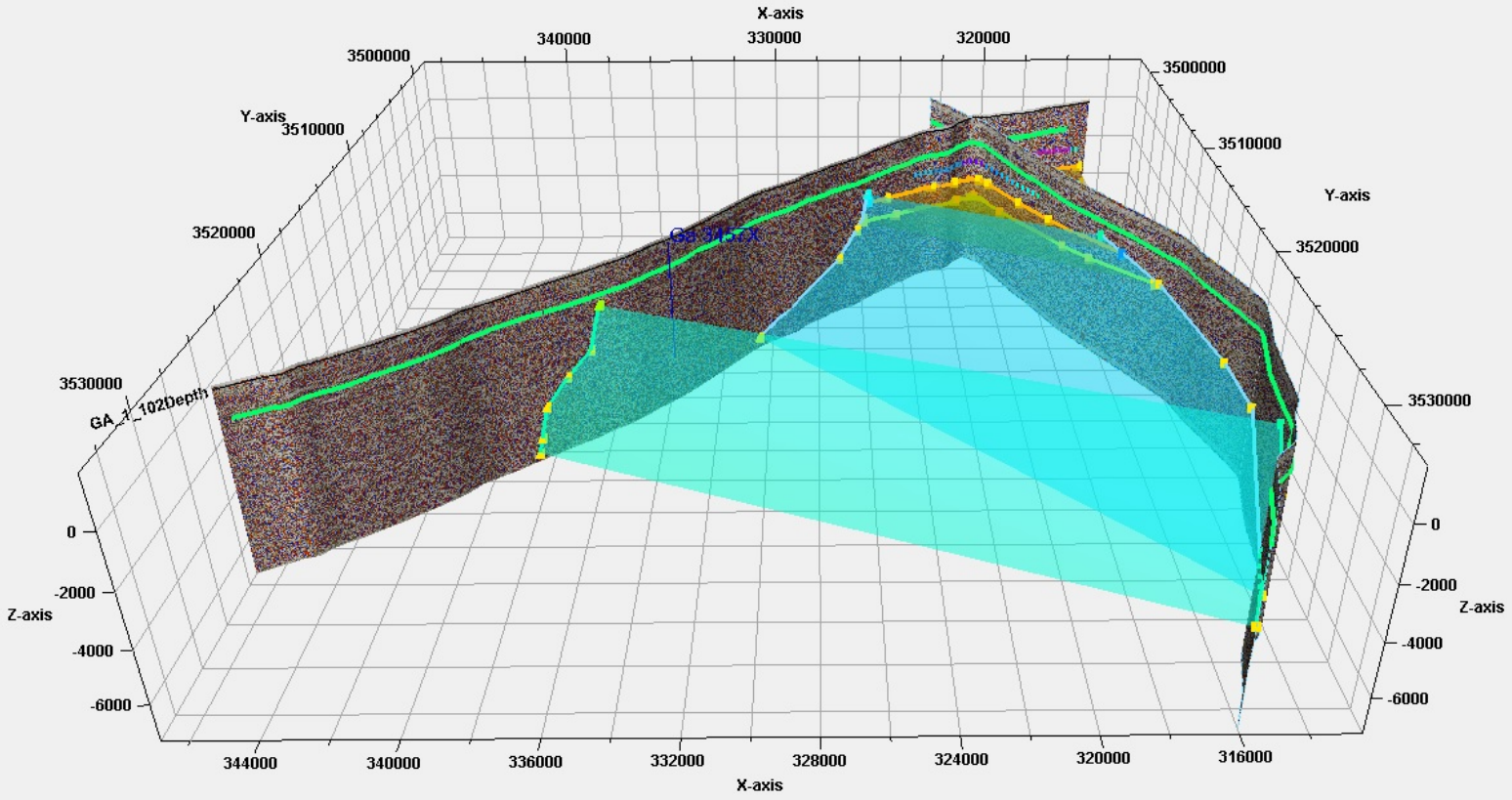
GA Seismic Survey



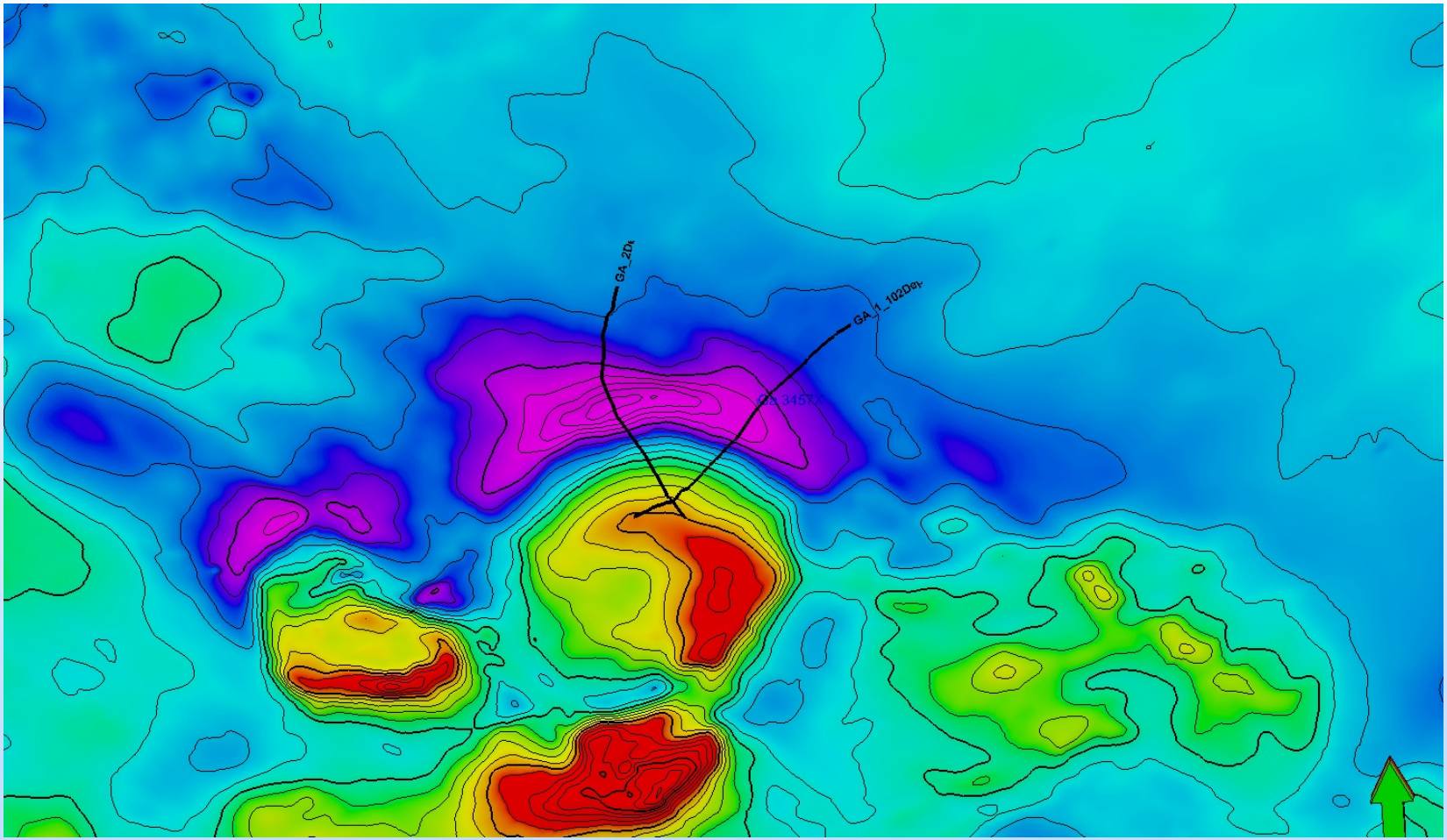
Seismic Line GA-2



3D View


X-axis
340000
330000
320000
3500000
Y-axis
3510000
3520000
3530000
GA_1_102Depth
0
-2000
Z-axis
-4000
-6000
344000
340000
336000
332000
328000
324000
320000
316000
X-axis
3500000
3510000
Y-axis
3520000
3530000
0
-2000
Z-axis
-4000
-6000

Aero Magnetic



Summary

Key Findings

- Certain subbasins within the SGR still appear to be capable of storing large quantities of CO_2 in compartmentalized, stacked storage reservoirs.
- The sandstone porosity and permeability values are so low in SC portion of the SGR they may act as caprock.
- In SC there is the possibility of using the fracture diabases as reservoir and clastic sediments as caprock.
- Run simulations injecting CO_2 into the diabase.
- In SW GA the SGR appears to have a different geologic history than the SGR in SC.
- There appears to be porosity in the clastic sandstones in this part of the SGR that are possible reservoirs.

Lessons Learned

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

Future Plans

- Conduct further research in the southern part of the South Georgia Rift Basin
- Further investigate the possibility of using the diabase intrusions as possible reservoirs