GEOLOGIC CHARACTERIZATION OF THE SOUTH GEORGIA RIFT BASIN FOR SOURCE PROXIMAL CO_2 STORAGE

South Carolina Research Foundation / University of South Carolina

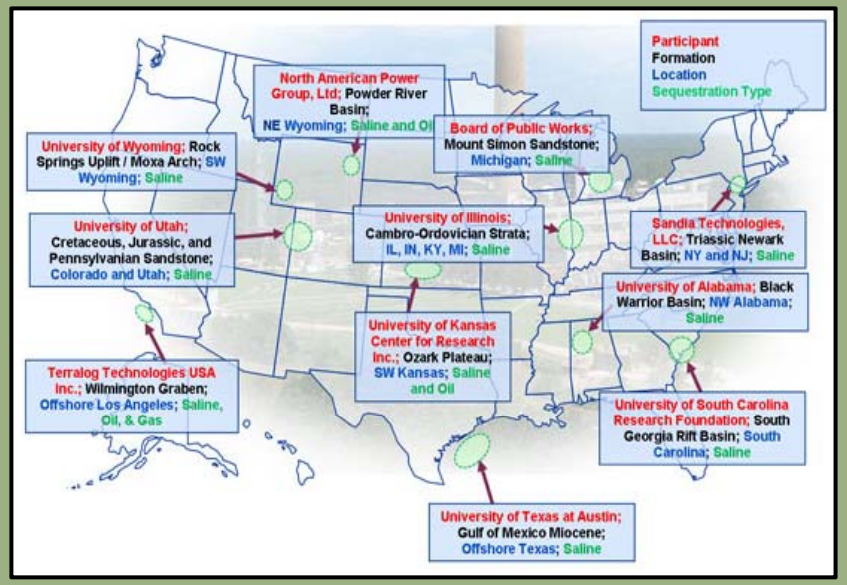
Sponsor

U.S. Department of Energy, National Energy Technology Laboratory

"Site Characterization of Promising Geologic Formations for CO_2 Storage"

December 8, 2009 through December 7, 2011
$4,950,639 DOE/NETL Award

The Department of Energy is funding 11 projects valued at $75.5 million aimed at increasing scientific understanding about the potential of promising geologic formations to safely and permanently store carbon dioxide.



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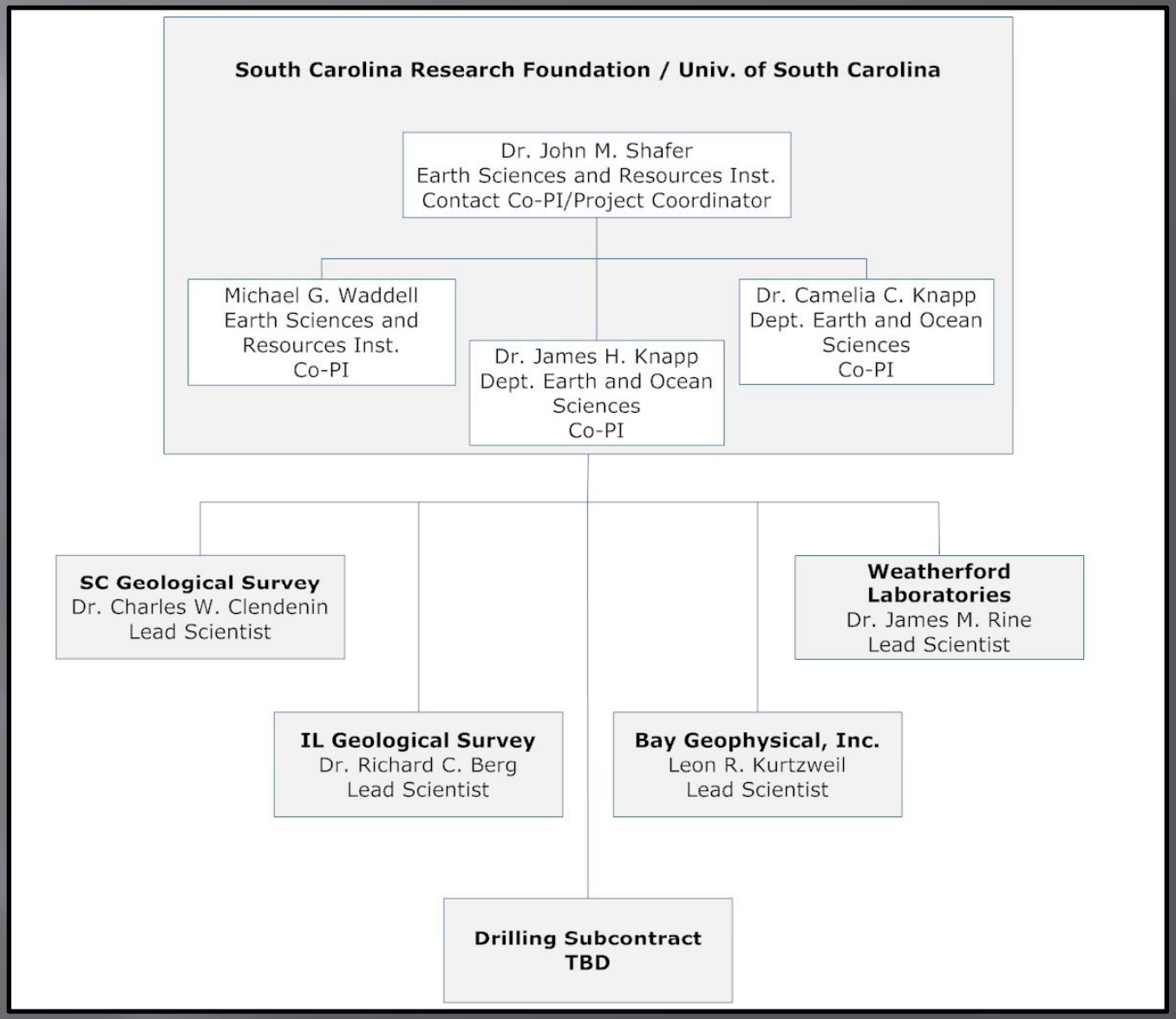
Research Team



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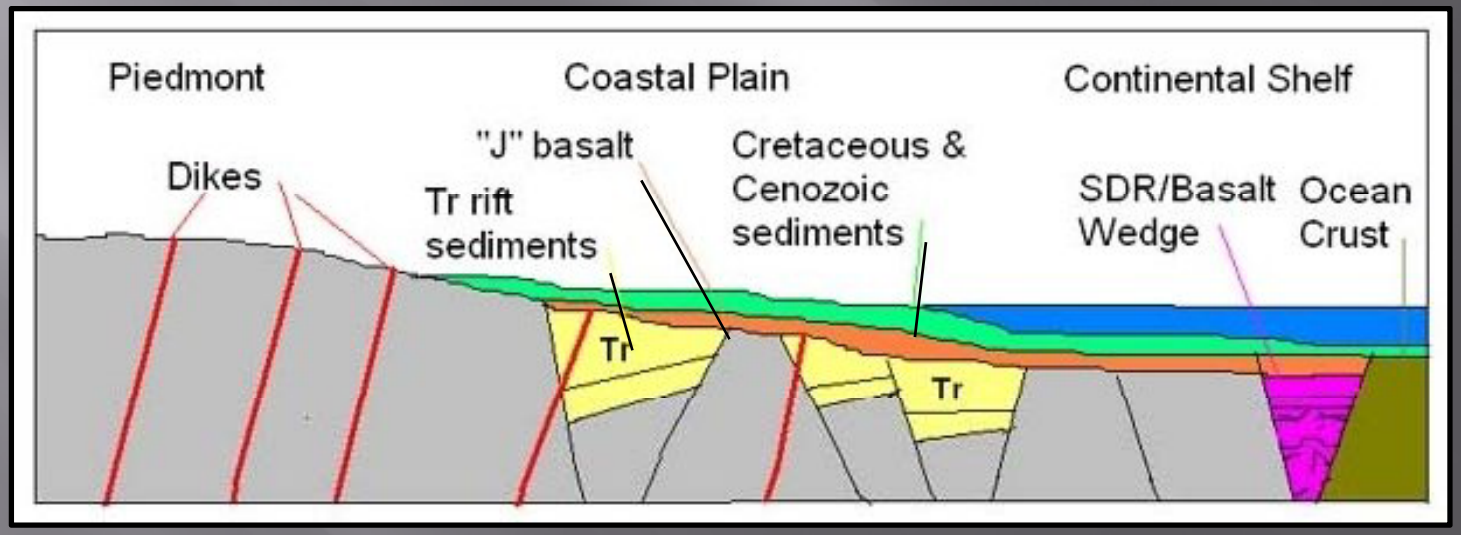
Description

South Georgia Rift Basin (SGR) – Buried Mesozoic basin extending west-southwesterly from South Carolina into Georgia that formed along zones of faulting and subsidence during the period of crustal extension associated with the breakup of Pangea.



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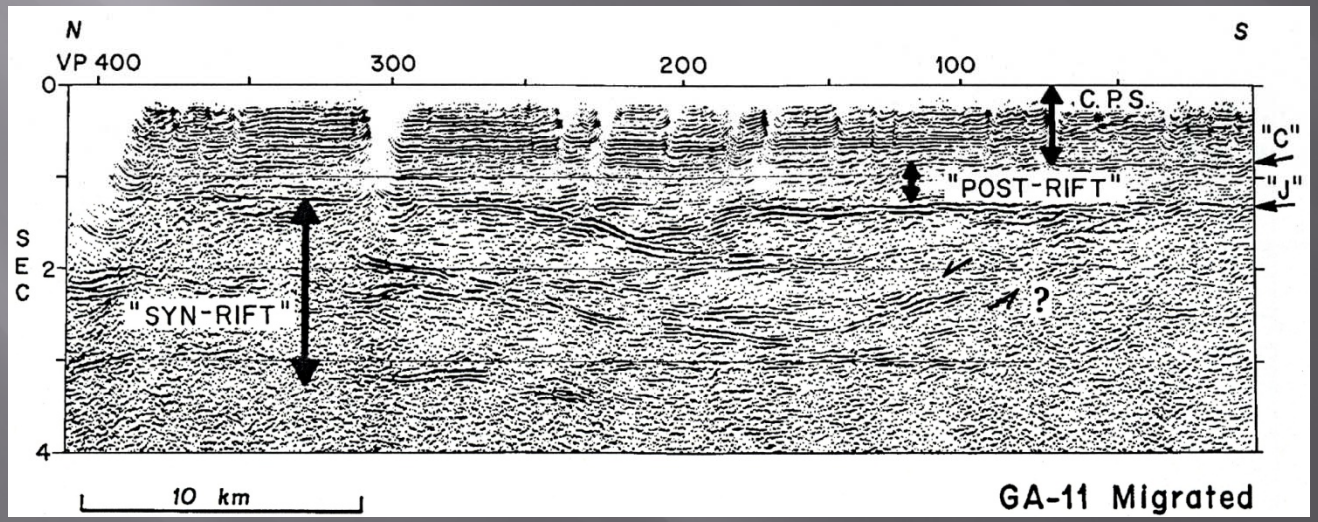
South Georgia Rift Basin

- Related(?) to Triassic Newark basins
- Buried entirely beneath the Southeast Coastal Plain
- Covers area over 160,000 km^2
- Thickness of the basin fill may be up to 6 km
- Basin fill mostly fine to coarse grained sandstones, conglomeritic sandstones, mudstones, and siltstones – redbeds with intercalated layers of basalt/diabase
- Overlain by Jurassic basalt ("J" horizon) that is greater than 250 m thick in some parts of the basin



Continental Reflection Profiling (COCORP) line GA-11 located in southern Georgia from McBride, et al., 1989. This 1980's vintage seismic line images the base of the Coastal Plain sediments "C" and the post rift sediments and "J" Basalt extending into southern Georgia.

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Characterization Hypothesis

South Georgia Rift Basin (SGR) is capable of storing large quantities of CO_2 and multiple caprock formations are present to maintain the integrity of the storage of CO_2 as a supercritical fluid.

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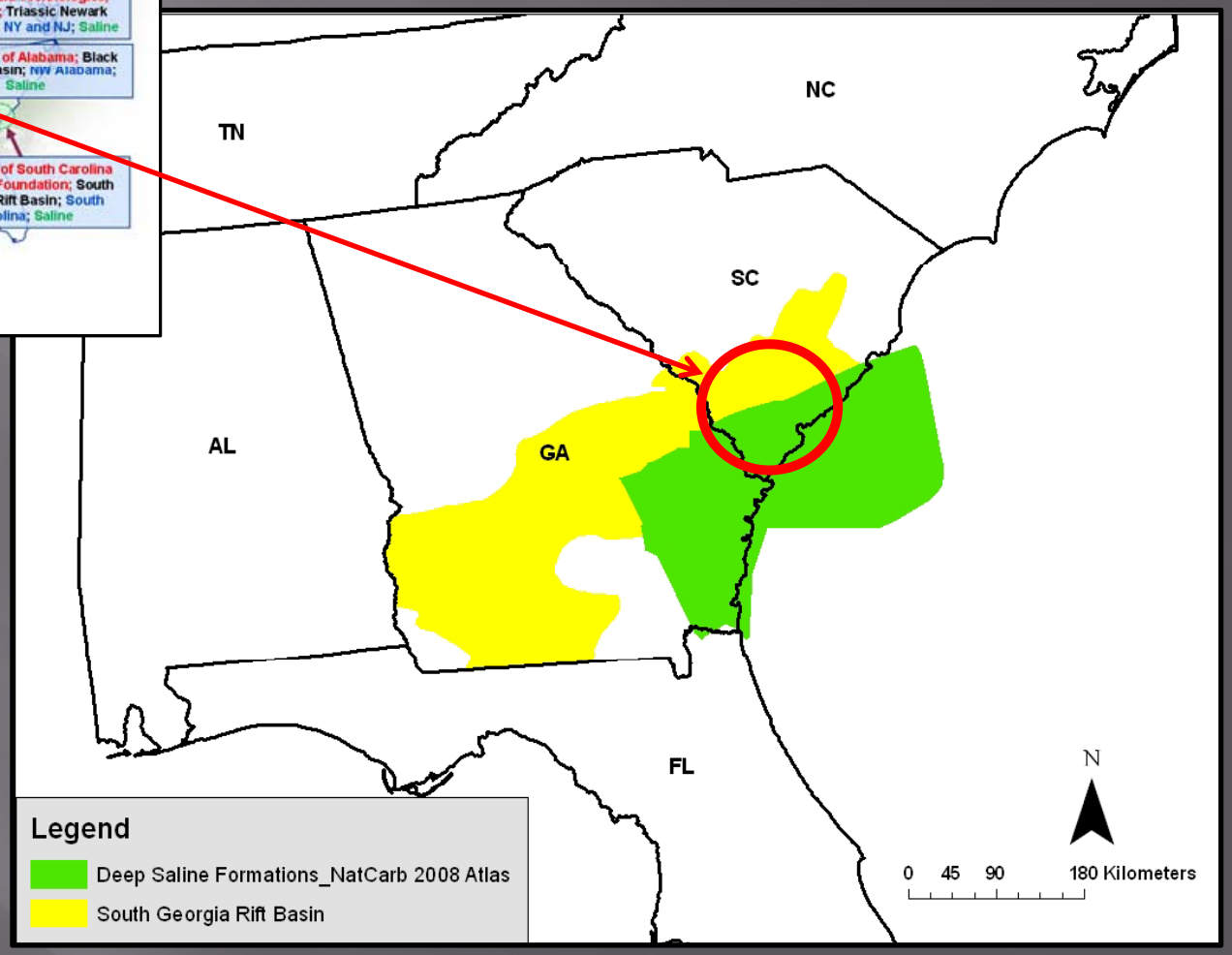
Location of Study



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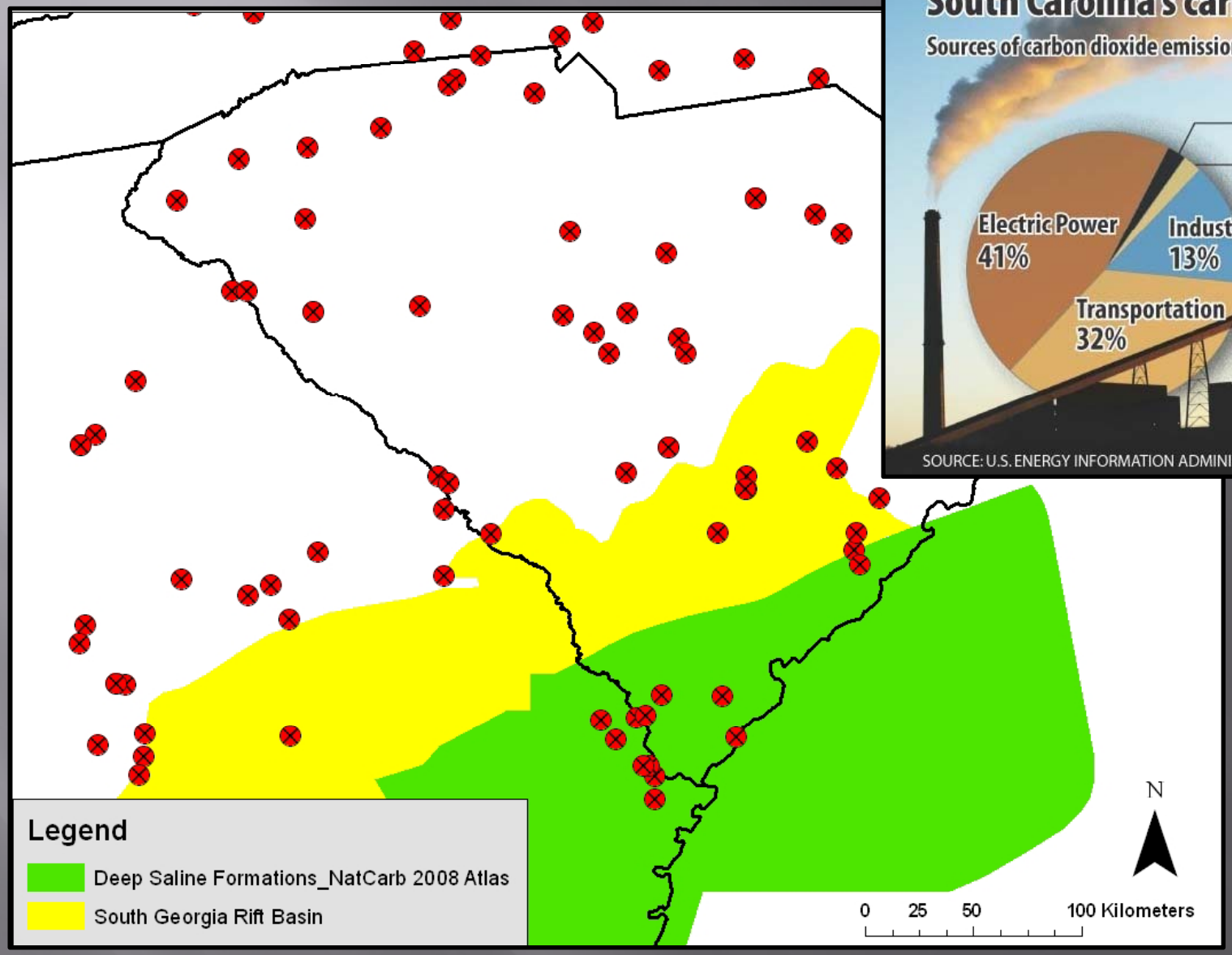
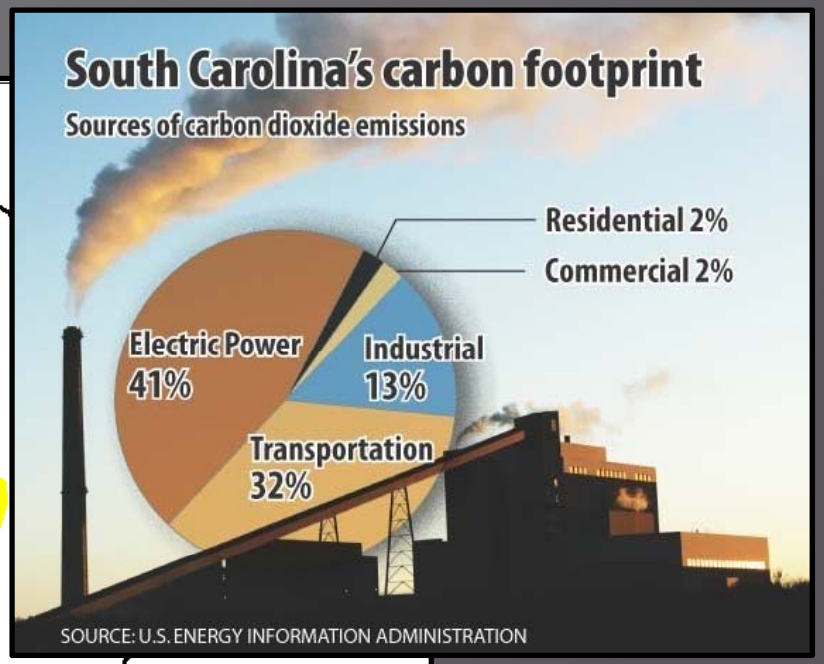
CO_2 Sources





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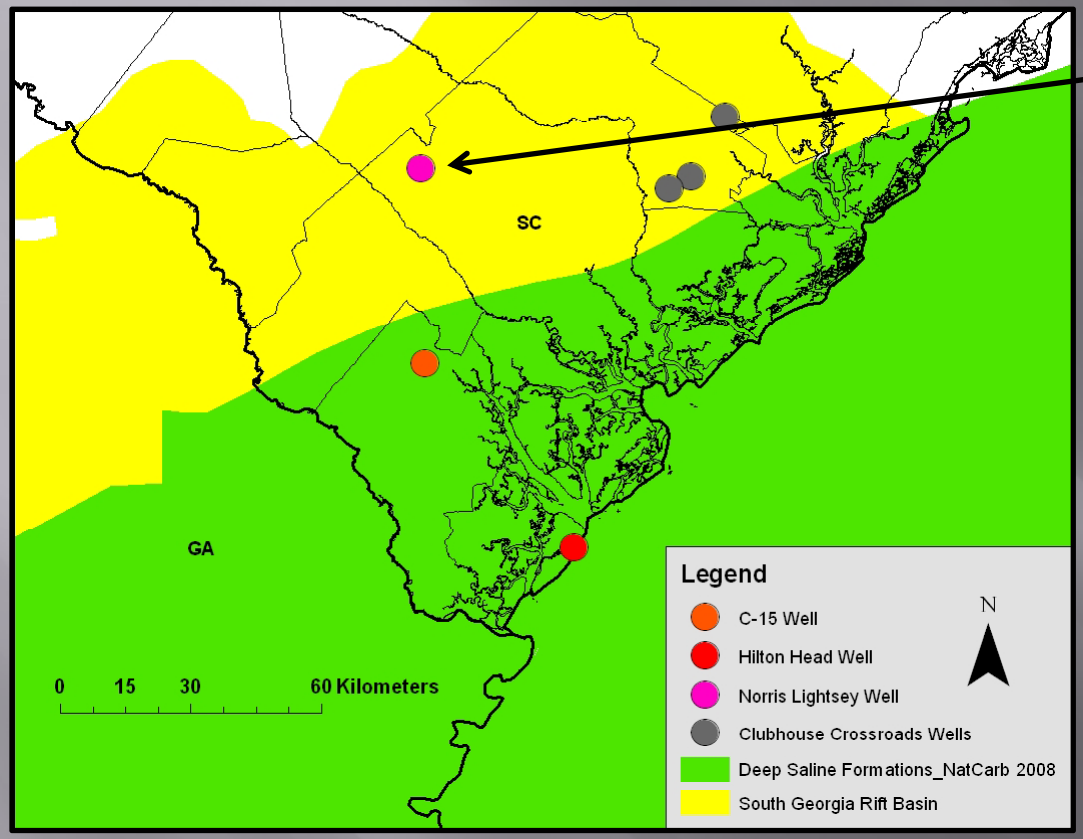
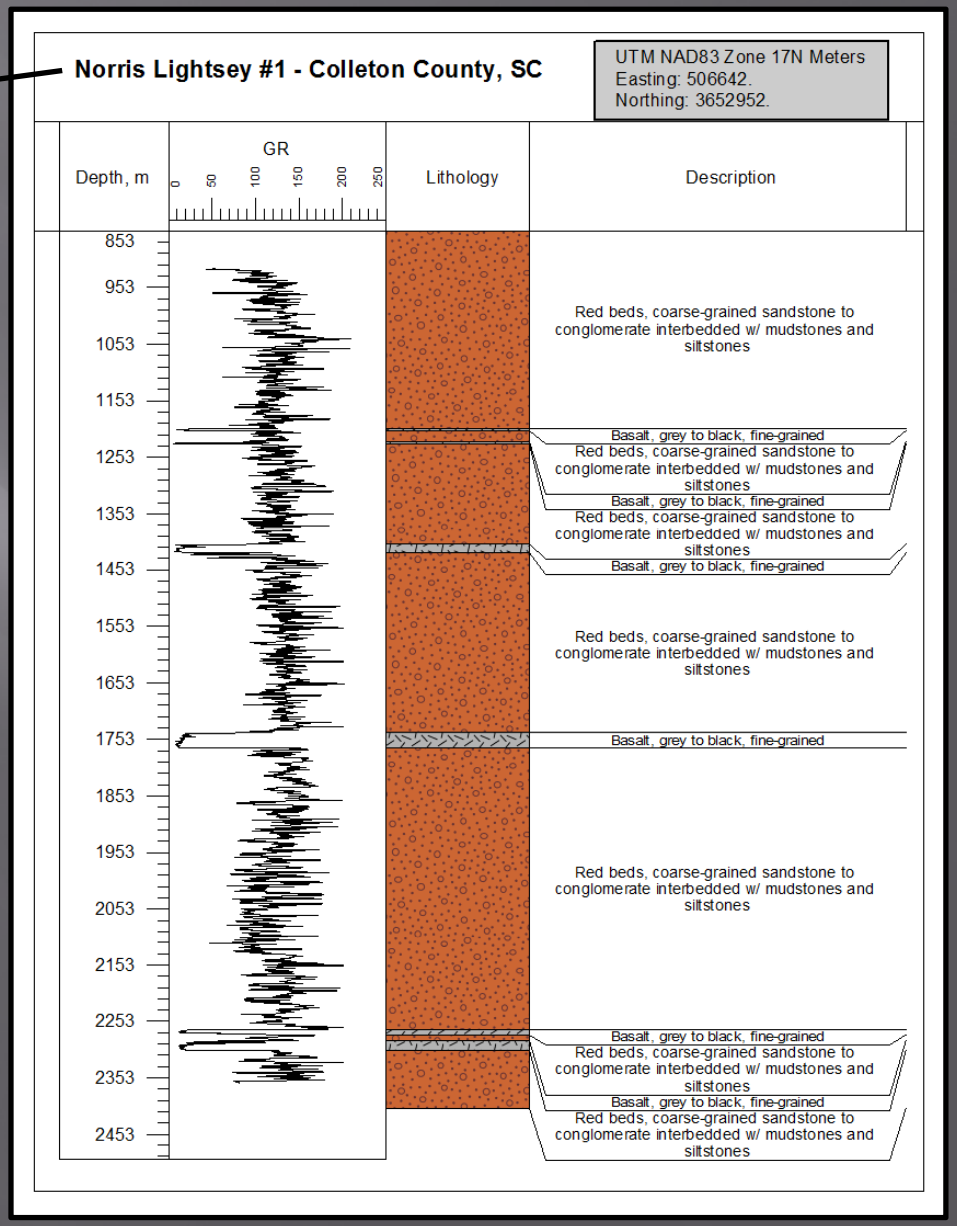
Preliminary Understanding of the Geology of the Study Area





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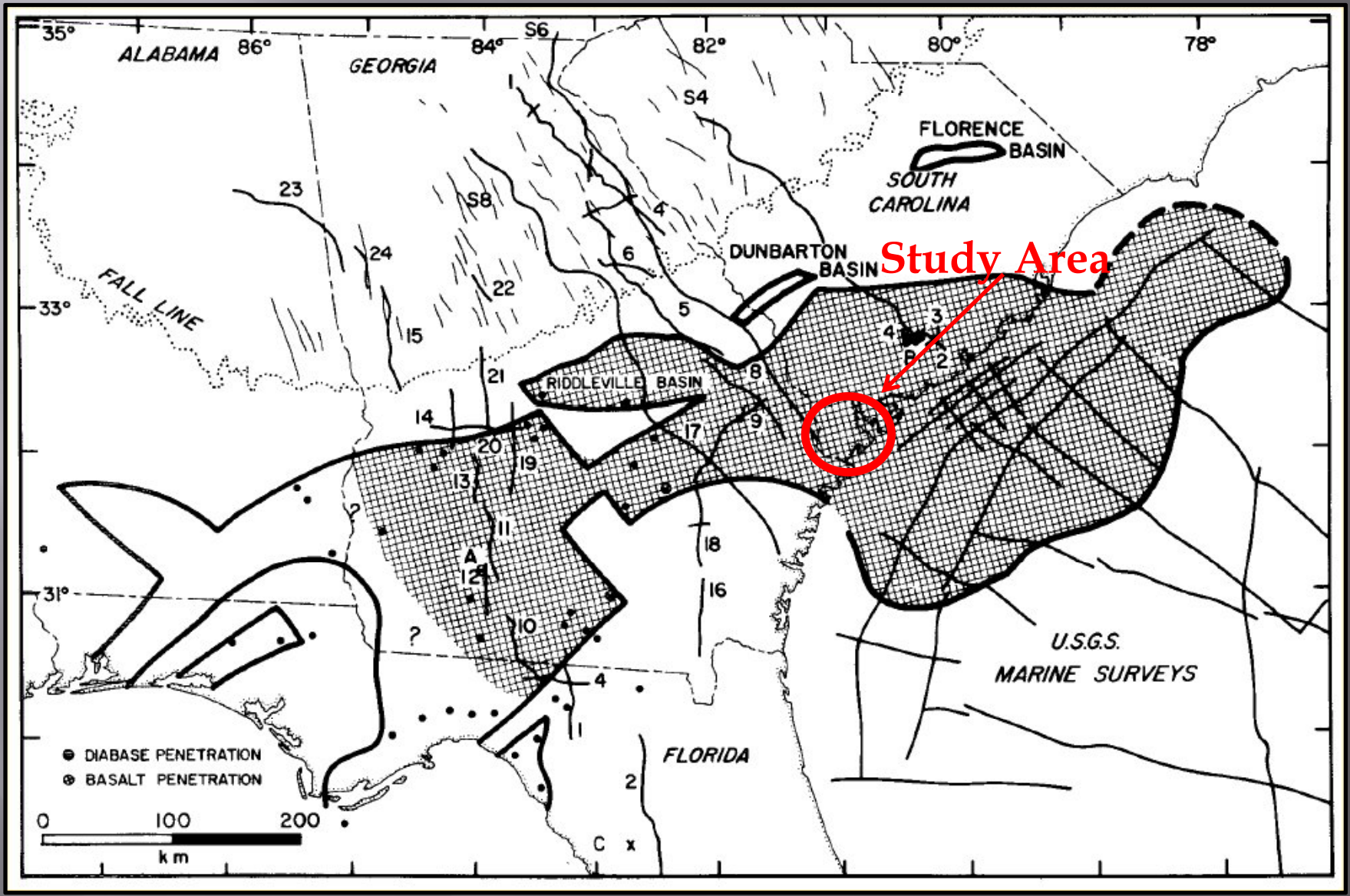
Areal Extent of "J" Basalt Layer



Source: McBride, et al., 1989

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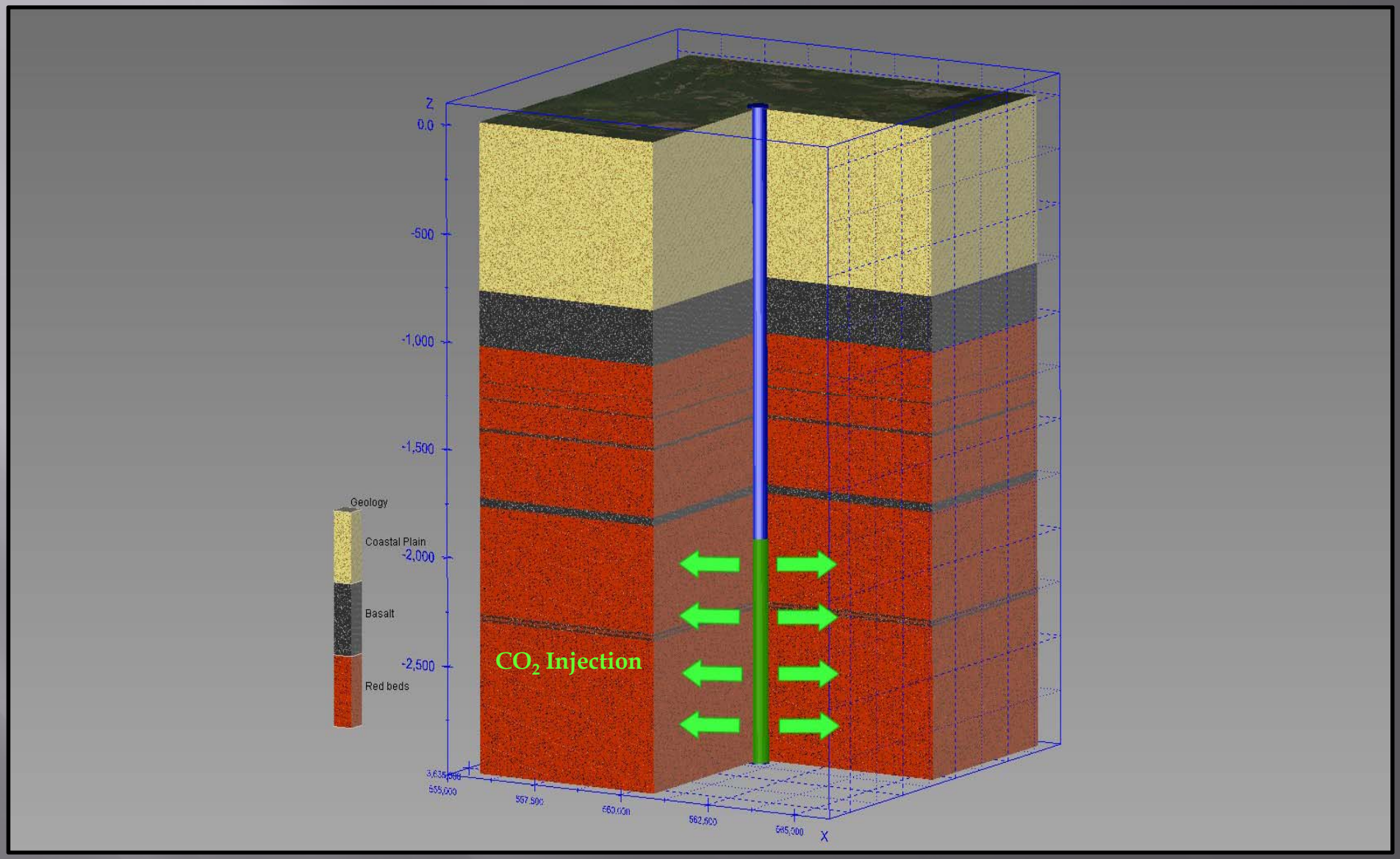
Conceptual Solid Earth Model



DOE (2006) CO_2 Storage Capacity Estimation for Saline Formations

$$G_{CO2} = A \times h_g \times \phi_{tot} \times \rho \times E$$

Where: G_{CO_2} = Mass estimate of saline formation CO_2 storage capacity (M)

A = Geographical area (footprint) that defines the basin (L^2)

h_g = Gross thickness of saline formation defined by A (L)

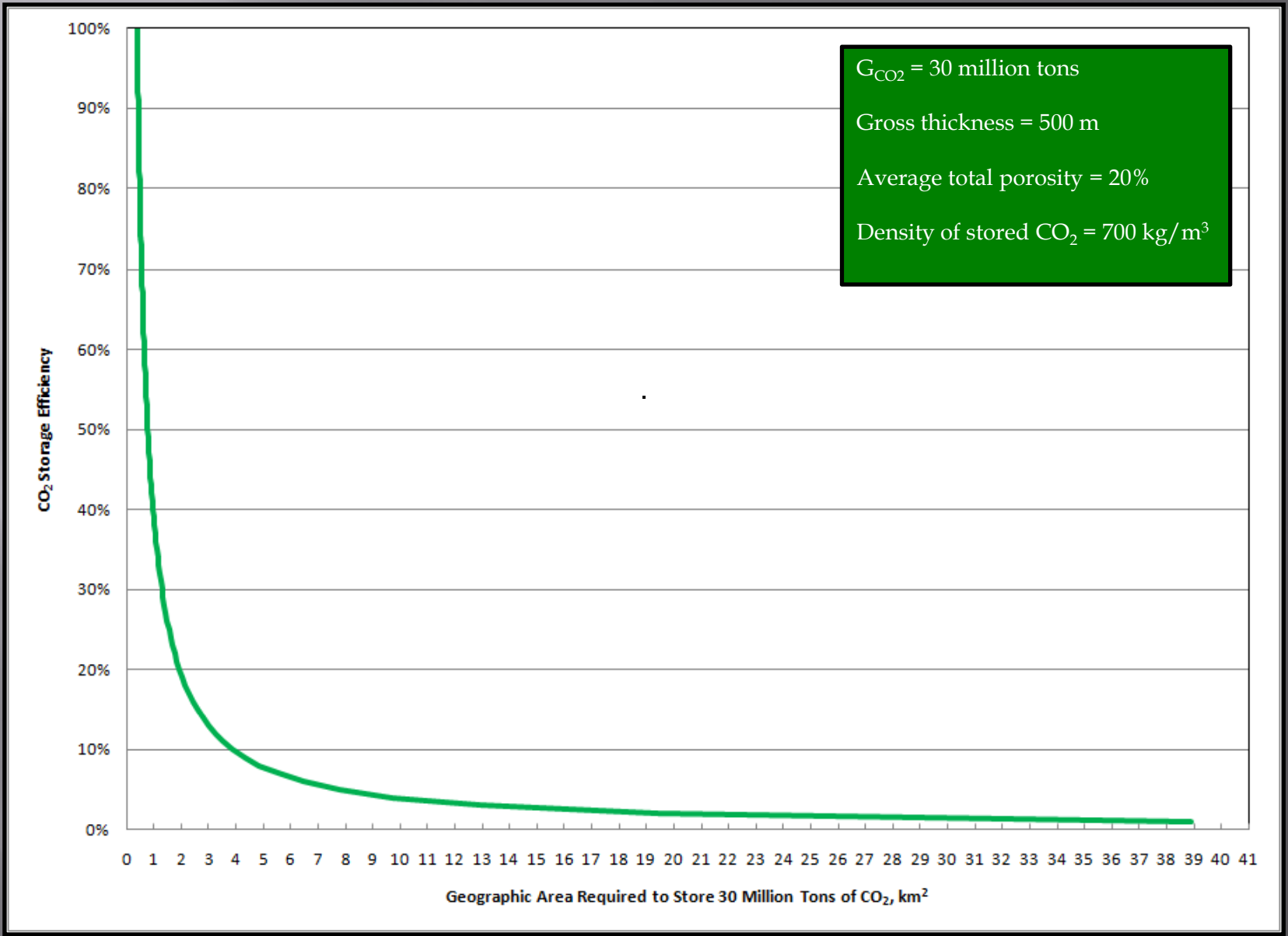
φ_{tot} = Average total porosity over hg (L^3/L^3)

ϱ = Density of CO_2 at pressure and temperature that represents storage conditions (M/L^3)

E = Storage efficiency factor – fraction of total pore volume that is filled (L^3/L^3)

Rearranging terms: $$A = \frac{G_{CO2}}{(h_g \times \phi_{tot} \times \rho \times E)}$$

DOE (2006) CO_2 Storage Capacity Estimation for Saline Formations



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Characterization Approach

Three Phases:

1. Preliminary geologic storage assessment based on existing data and analyses including re-interpretation and integration of existing data (Year 1)

2. Regional characterization of target CO_2 storage formation (Year 2)

3. Site-specific characterization via drilling, coring, logging geotechnical test hole (Year 3)

Phase 1

Phase 2

Phase 3

Spatial Scale Refinement

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Phase 1: Preliminary Geologic Storage Assessment

Task 1: Project Planning and Management

- 1.1 – Revise Project Management Plan
- 1.2 – Conduct Planning and Reporting
- 1.3 – Develop Interface Capability to NATCARB Database
- 1.4 – Develop Project Web Site

Task 2: Determine and Evaluate Characteristics of Mesozoic Reservoirs in SGR

- 2.1 – Gather and Assess Existing Geologic/Geophysical Formation Data
- 2.2 – Determine Structural Controls on Mesozoic Reservoirs in SGR with Existing Seismic Data
- 2.3 – Identify Favorable Injection Targets
- 2.4 – Estimate Regional Significance of Target Injection Formations on Basis of Known Analogs of Eastern US Triassic Basins
- 2.5 – Estimate CO_2 Storage Capacity
- 2.6 – Estimate Containment Effectiveness
- 2.7 – Decide if Further Investigation is Warranted ("Go/No Go" Decision)

GEOLOGIC CHARACTERIZATION OF THE SOUTH GEORGIA RIFT BASIN FOR SOURCE PROXIMAL CO_2 STORAGE

Project Data Dissemination

Interface to NATCARB Database

Project Web Site to provide data, interpretations, educational materials, videos, and presentations that track the progress of our research and can be accessed and used by a broad audience.

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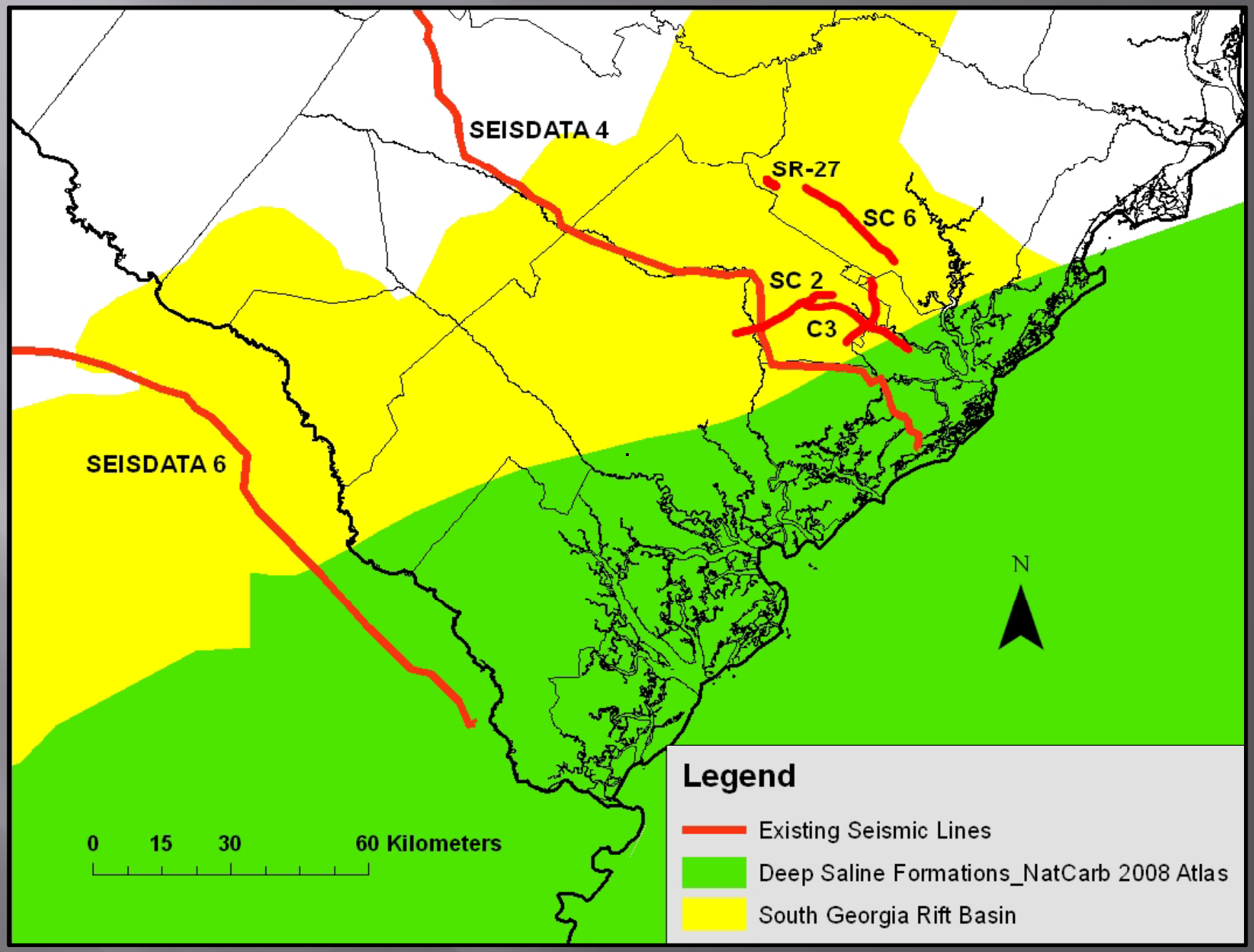

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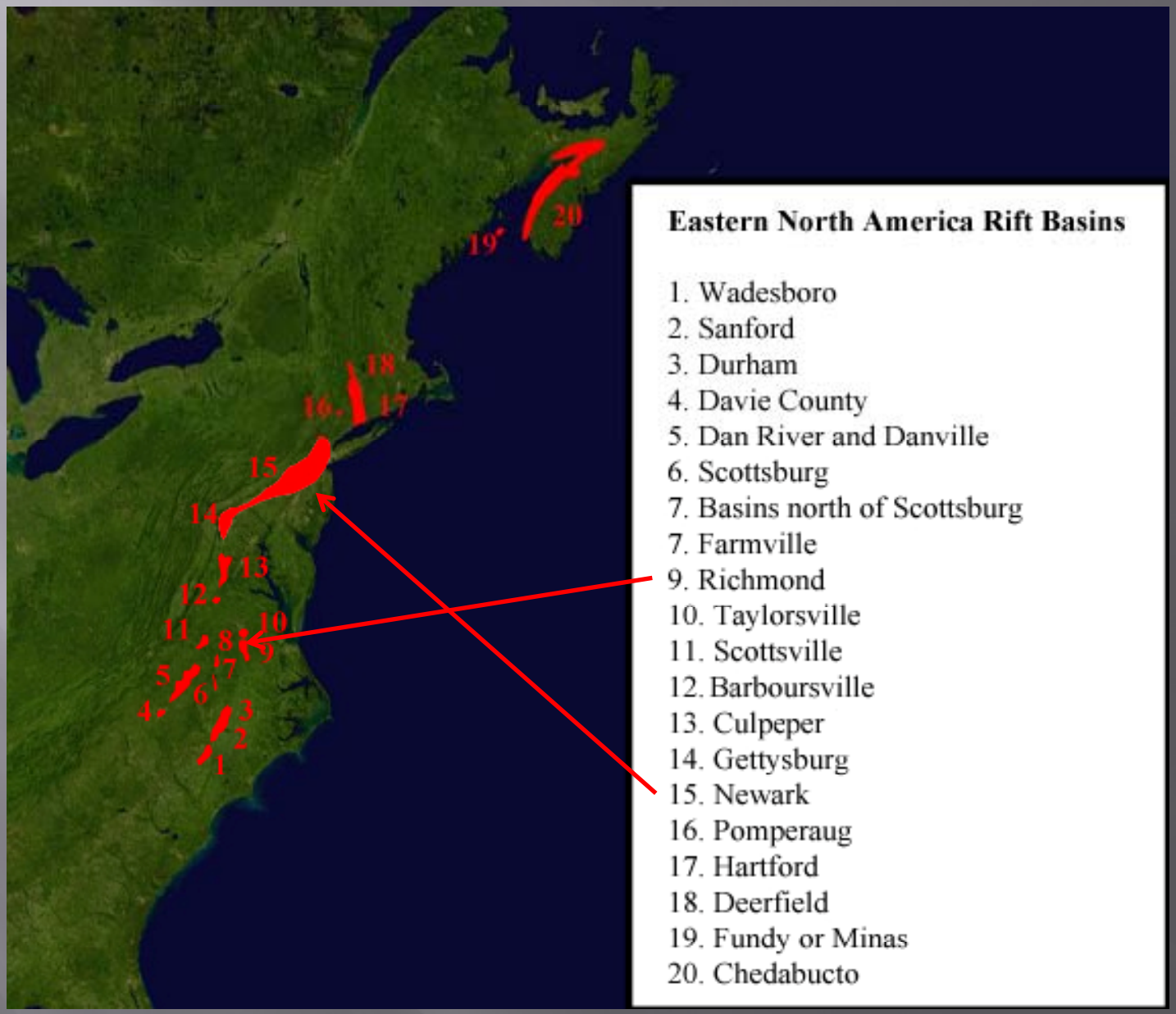
Analog Mesozoic Basins



Eastern North America Rift Basins

1. Wadesboro
2. Sanford
3. Durham
4. Davie County
5. Dan River and Danville
6. Scottsburg
7. Basins north of Scottsburg
7. Farmville
9. Richmond
10. Taylorsville
11. Scottsville
12. Barboursville
13. Culpeper
14. Gettysburg
15. Newark
16. Pomperaug
17. Hartford
18. Deerfield
19. Fundy or Minas
20. Chedabucto

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Analog Mesozoic Basins

Basin Name	Pros	Cons
Dunbarton Basin	• Well Studied buried basin • Close Proximity to SGR	• Rather small in comparison
Deep River Basin	• Nearest exposed basin	• Rather narrow basin • Strikes NE – SW
Newark Basin	• Best studied Triassic rift basin	• Either younger or active for longer time • Strikes NE – SW
Narrow Neck	• Strikes E – W, similar to SGR in South Carolina	• Not generally considered a separate basin

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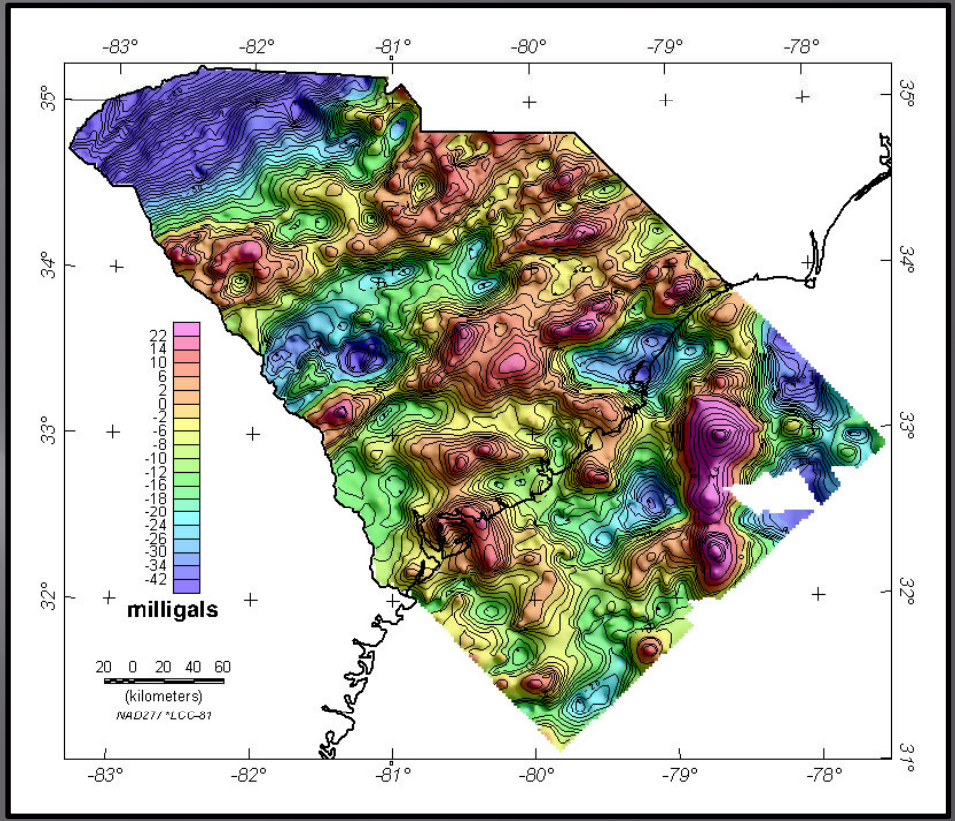
Gravity

- Anomalies
- Delineate geometry and lateral extent of basins
- Basins with low densities (sedimentary rocks) produce a (-) gravity anomaly
- In some cases, with other geophysical data, can be used to determine geometry of trap structures



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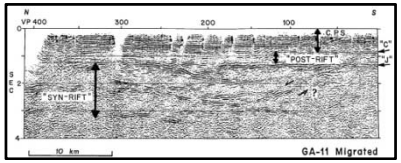
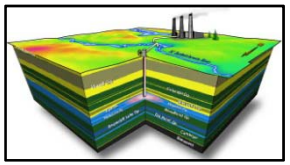
Phase 1 Initial Assessment Work Flow

Gather and Assess Existing Geologic/Geophysical Data

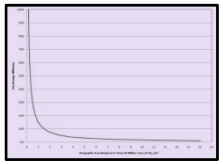


Determine Structural Controls on Mesozoic Reservoirs with Known Analogs

Identify Favorable Injection Zones and Containment Effectiveness



Estimate CO_2 Storage Capacity



"Go/No Go" Decision

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Phase 2: Target CO_2 Storage Formation Regional Characterization

Task 3: Assess Regional Significance with Additional Surface Seismic Surveys

Task 4: Refine Capacity Estimates Using Updated Conceptual Model Resulting from Task 3

Task 5: Simulate Injectivity into Target CO_2 Storage Formation

Task 6: Decide if Formation Characterization and Injectivity Evaluation Encourage Site-Scale Investigation ("Go/No Go" Decision)

Task 7: Select Test Hole Site and Develop Drilling Bid Package

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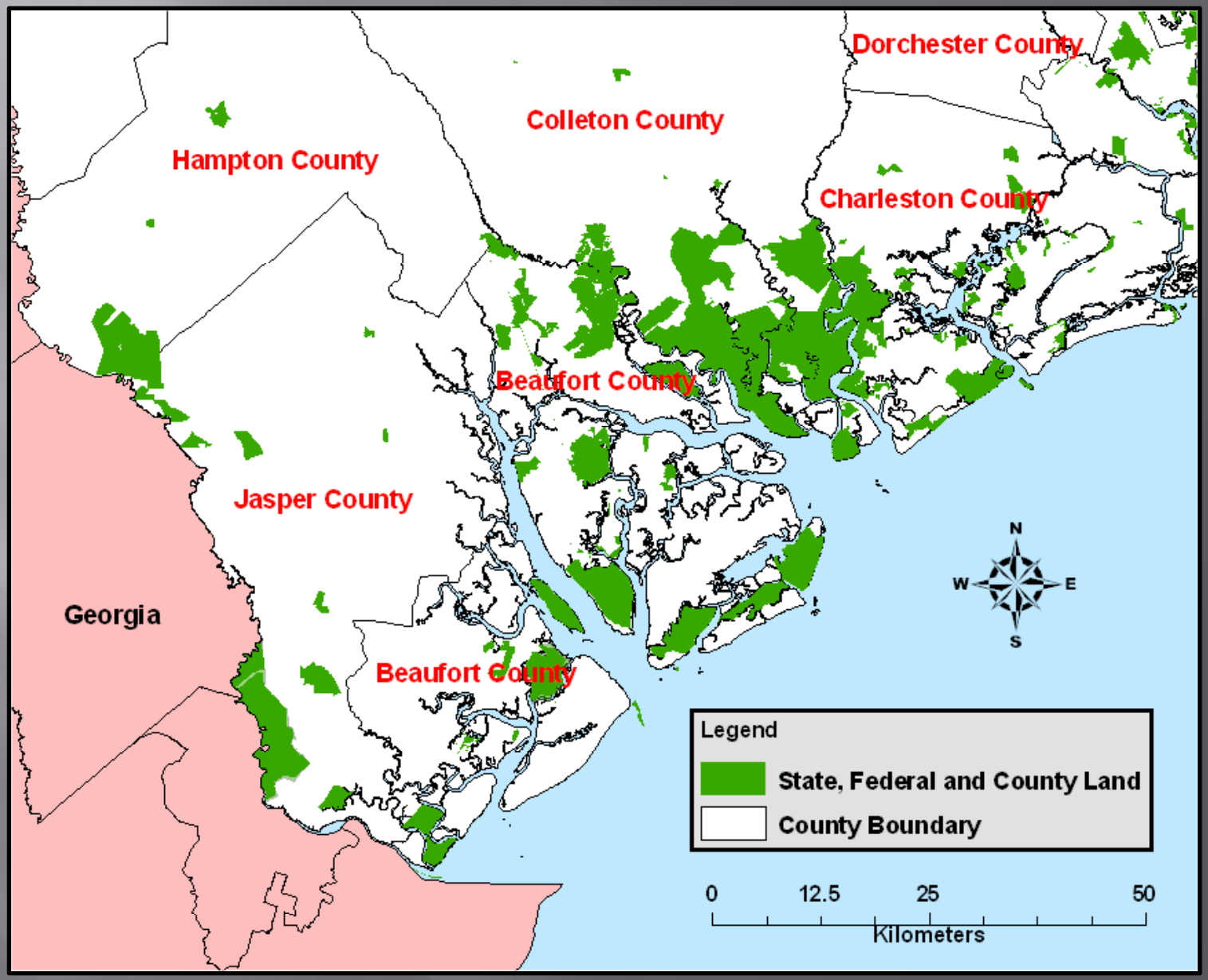
Public Lands within Study Area



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Reflection Seismic Survey

- Three test locations within study area
- 20 km of reflection seismic at each area
- Lines located along public roads
- Depth penetration equal to 5,180 m

Preliminary Acquisition Parameters

Number of Channels	320 channels
Group Interval	110 feet
Source Interval	110 feet
Source	1(each) IVI Advance Technology System Vibrator (62,000 force lbs with advance torque amp control system)
Sweep Parameters	8 Hz to 100 Hz, 8 each-12 second sweeps
Record Length	4 seconds
Sample Rate	2 ms
Geophone Array	12 (each) Oyo GeoSpace Geophones-10 Hz over 110 feet

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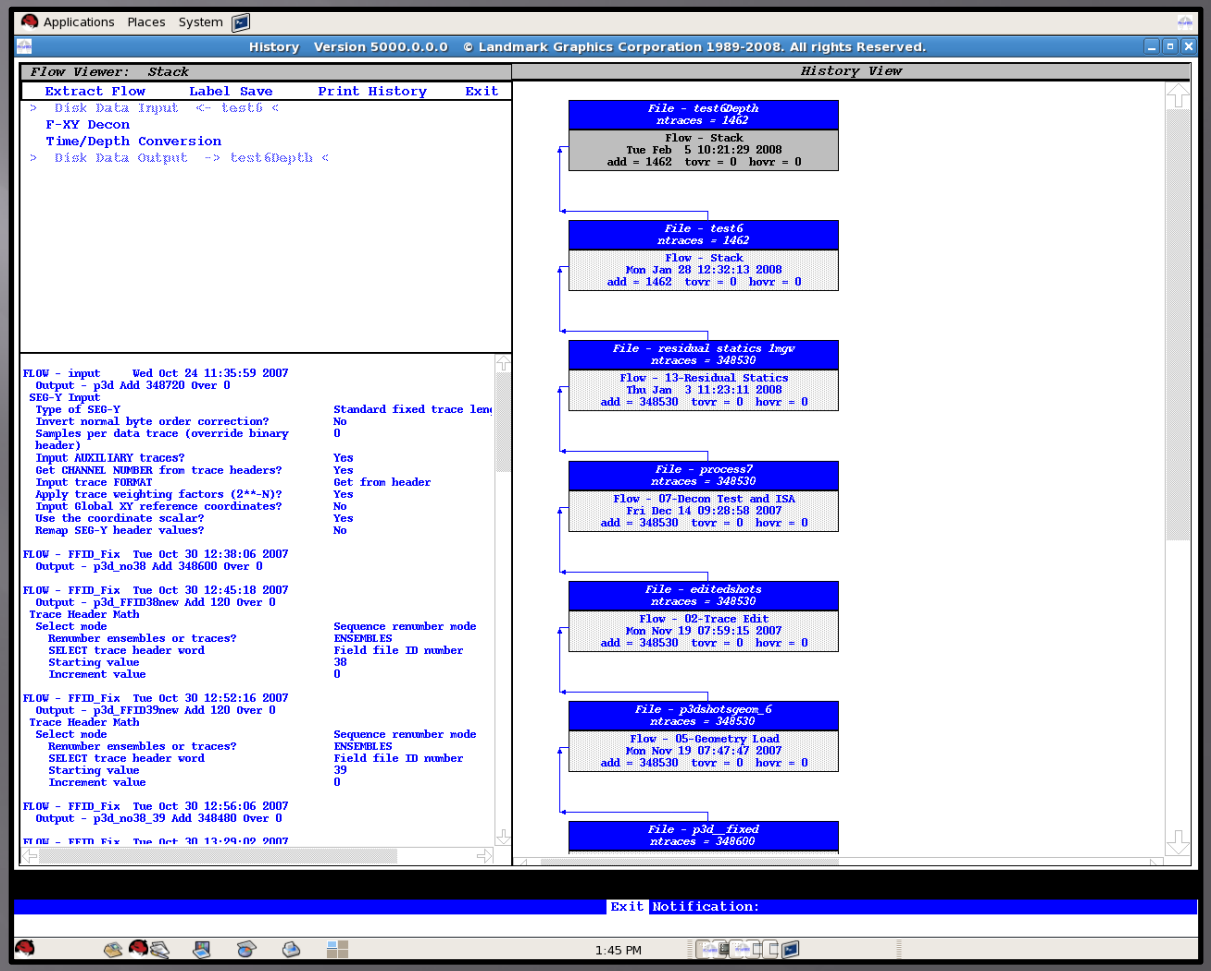
Conventional CDP Data Processing Flow Overview

- Trace editing
- Geometry
- Increase signal-to-noise ratio
- Velocity analysis
- CDP stacking
- Depth conversion



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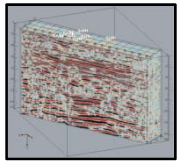
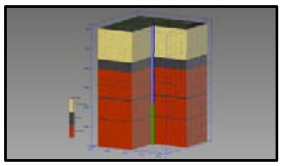
Phase 2 Data Integration and Solid Earth Modeling Work Flow

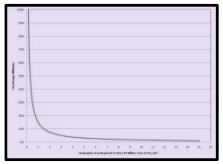
Integrate New Seismic Data with Phase 1 Existing Data



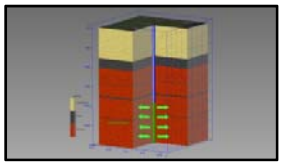
Refine Solid Earth Model



Update CO_2 Capacity Estimates



Simulate Injectivity into Formation



"Go/No Go" Decision

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Phase 3: CO_2 Storage Containment Assessment

Task 8: Drill/Core Caprock and Formation

Task 9: Assess Caprock and Storage Formation Containment

- 9.1 – Perform Stratigraphic Characterization of Caprock
- 9.2 – Simulate Dissolution of CO_2 into Brine in Formation
- 9.3 – Assess Rate of Mineralization

Task 10: Determine the Presence of Leakage Pathways

Task 11: Identify Site Attributes that May Pose Risks to Operations

Task 12: Develop Wellbore Management Plan

Task 13: Test Hole Abandonment

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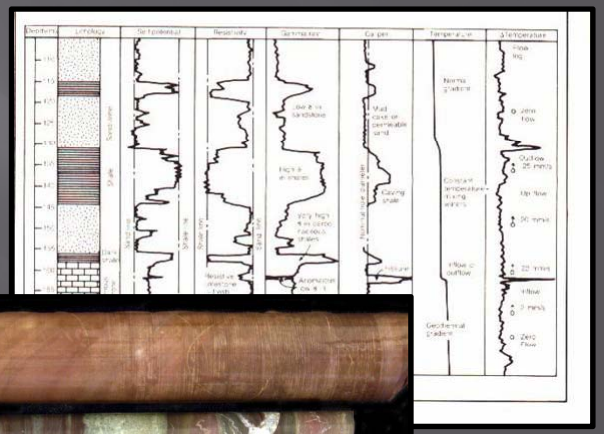
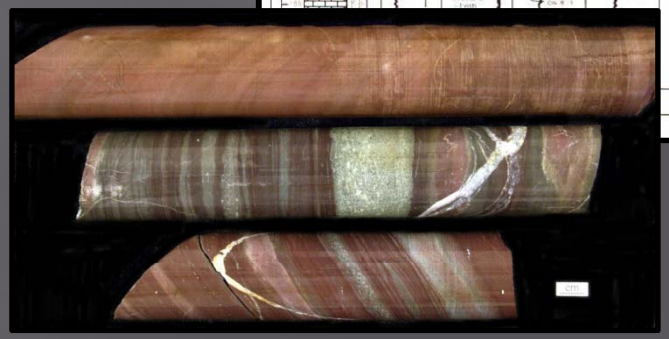
Drilling and Coring

- Site selected from Phase 2 investigation
- > 2,600 m (8,500 ft) deep test hole
- Wireline logging including but not limited to:
  - NMR
  - Gamma-gamma
  - Gamma ray spectral
  - Neutron density
  - Induction
  - Dip Meter
  - Photo-electric
  - Sonic
- Core extraction:
  - 18.3 m (60 ft) of caprock
  - 54.9 m (180 ft) of potential reservoir





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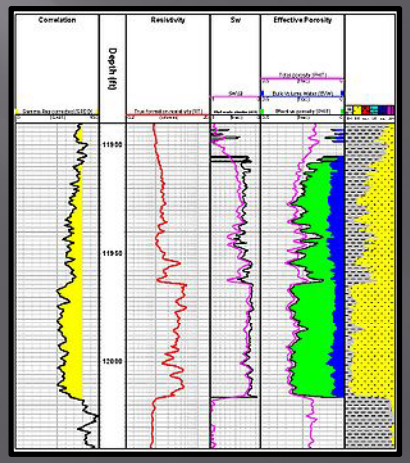
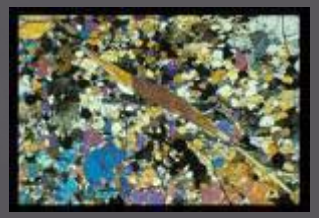
Core Analysis

- Petrologic analyses (9.1):
  - Field logs
  - Wireline logs
  - Inspection of core
  - Laboratory analysis of core (XRD, SEM, rock mechanics, K, φ, etc.)
  - Thin section
- Rate of dissolution of CO_2 into brine (9.2):
  - Solubility of CO_2 in brines
  - Interfacial tension
  - Sorption properties
- Rate of mineralization (9.3):
  - Solid mineral dissolution modeled based on brine character and reservoir conditions – predict effects on injectivity and permanent CO_2 storage capacity





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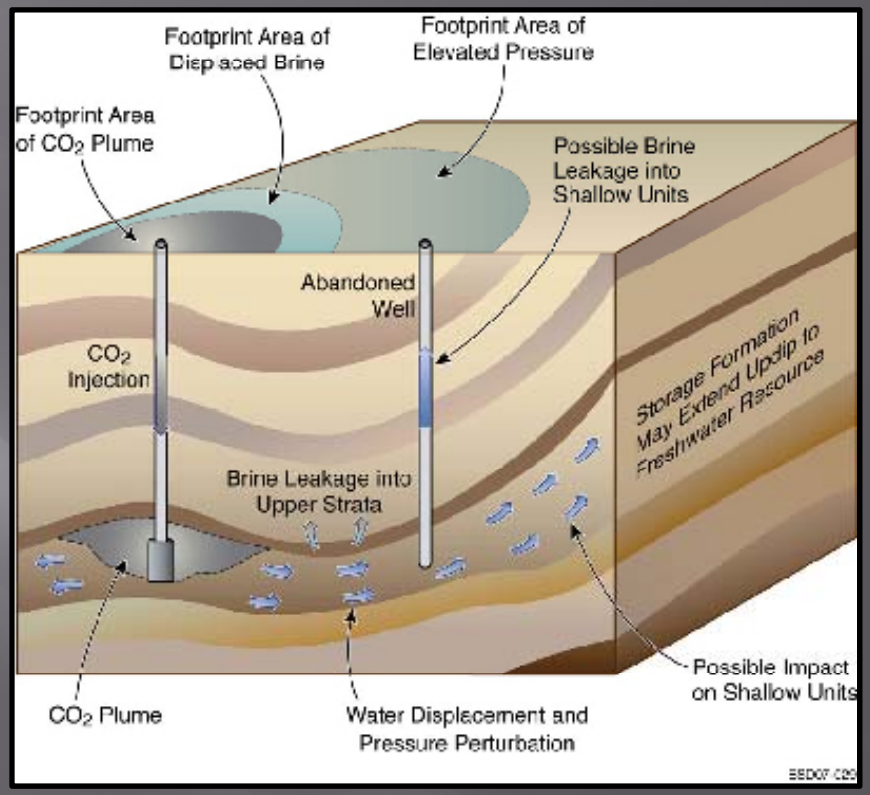
Determine Presence of Leakage Pathways – Seismic Interpretation

Leakage pathways:

- Leakage from the target reservoir
- Leakage via the injection well
- Leakage via abandoned wells

Evaluate faults, fractures, and caprock integrity

Sequence stratigraphic assessment of lateral facies distribution



Source: Lawrence Berkeley National Laboratory

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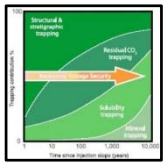
Phase 3 Site-Specific Characterization Work Flow

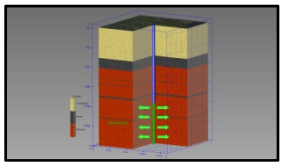
Drill/Log/Core Test Hole

Assess Caprock and Storage Formation Properties and Brine Interaction

Evaluate Leakage Pathways



Finalize Conceptual Model of SGR and Simulate Injection



Identify Site Attributes that Pose Risks to Operations

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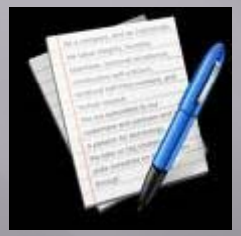
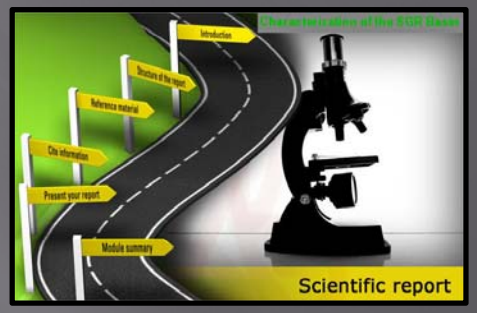
Phase 3 Concluding Activities



- Develop Wellbore Management Plan

- Test Hole Abandonment

- Final Scientific/Technical Reporting



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Questions?