Reinterpretation of the "J" Basalt Reflector from Seismic Data Reprocessing Across the Coastal Plain of Southeastern Georgia: Potential Implications for Long-Term CO_2 Sequestration*

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Abstract

We present new results focused on the regional significance of the Jurassic basalt ("J" basalt) within the Late Triassic South Georgia Rift (SGR) basin and its potential as a seal for CO_2 storage. The SGR basin which covers parts of Georgia, western Florida, southern Alabama and southern South Carolina, contains Triassic rocks that are deep enough to be classified as saline formations and are close to CO_2 emission sources, making them promising for geologic CO_2 sequestration.

The objective of this work is to identify and interpret subsurface reservoirs and seals as part of a basin-scale geological assessment for potential CO_2 storage. Contrary to the paradigm that the "J" basalt is present beneath the Cretaceous sediments in southeastern Georgia and parts of the (SGR) basin, our seismic imaging results corroborated by interpretation from nearby Georgia well data provide evidence to suggest that no pre-Cretaceous rocks are above the SGR in southeastern Georgia.

This new seismic imaging involved reprocessing of 96-channel, 6s and 24 fold seismic reflection data (SEISData6) covering the Coastal Plain of southeastern Georgia. Reprocessing was enhanced by the use of residual statics in addition to the attempt to boost signal to eliminate the background noise. Of primary importance to our interpretation is the presence of a conspicuous, southeast-dipping reflector with seismic characteristics similar to those previously described as the "J" reflector. However, our interpretation and subsequent correlation with a nearby Georgia well log indicates that this high-amplitude and fairly continuous reflector corresponds to the base of the Coastal Plain sediments and the transition to the underlying Triassic sediments. The "J" basalt, widely recognized in the 1980's as a distinct and prominent geologic marker that is either below or at the base of the Coastal Plain, does not appear to be present in the study area. Absence implies either a restricted spatial distribution of the "J" basalt or uplift and erosion, possibly

associated with fault reactivation. Our results further underscore the need for improved understanding of the geographical extent of the "J" basalt throughout the SGR basin. We conclude that the absence of the "J" basalt reflector from the study area does not preclude subsurface storage of CO_2. Substantial evidence abounds for the occurrence of diabase and shale that could serve as effective seals for potential CO_2 storage within the SGR basin.

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Outline

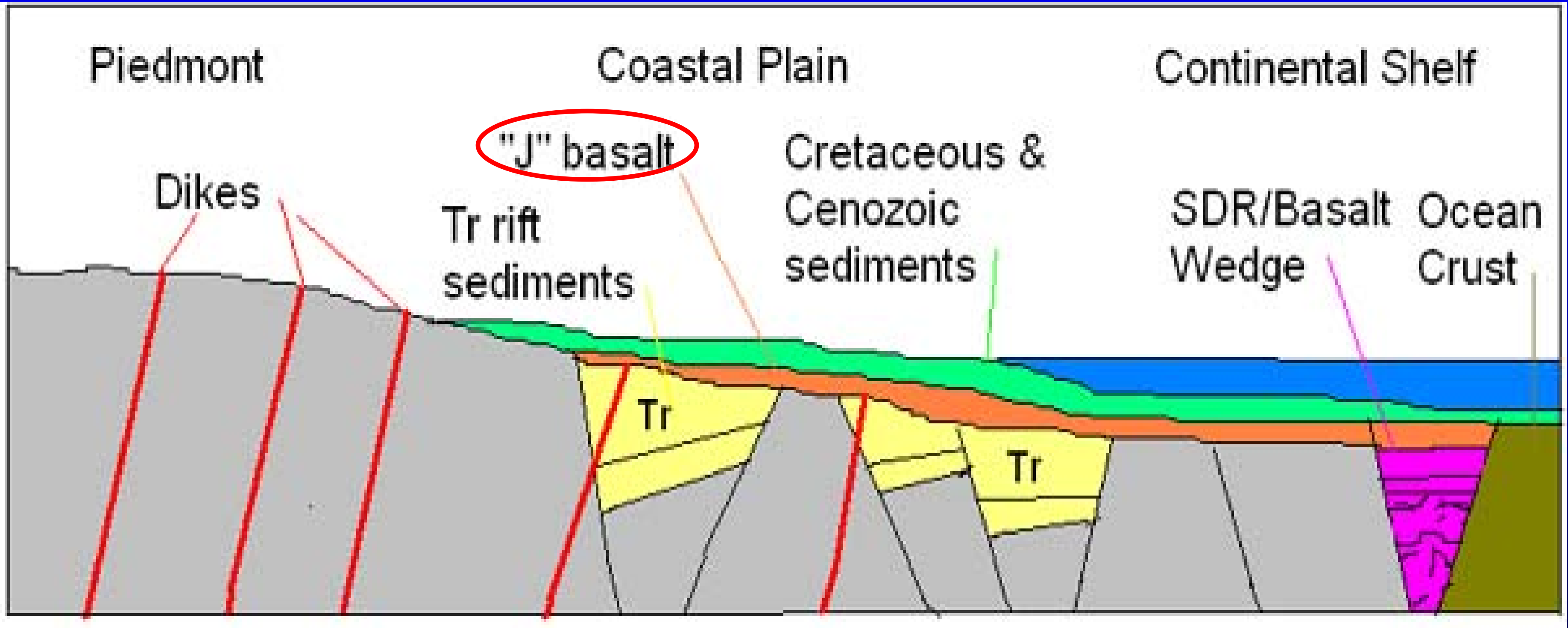
- Introduction
- Motivation
- Objectives
- Methods of Study
- Results and Interpretations
- Conclusions

Introduction

- "J" Basalt Reflector of early middle Jurassic (~ 184 Ma) - Lanphere, 1983
- It originated from Schilt et al 1983
  - based on correlations with the Clubhouse Crossroads basalt flows in South Carolina
- Interpreted as a laterally continuous, high-amplitude reflection (Hamilton et al. 1983)
- Associated with igneous activity during formation of South Georgia Rift basin

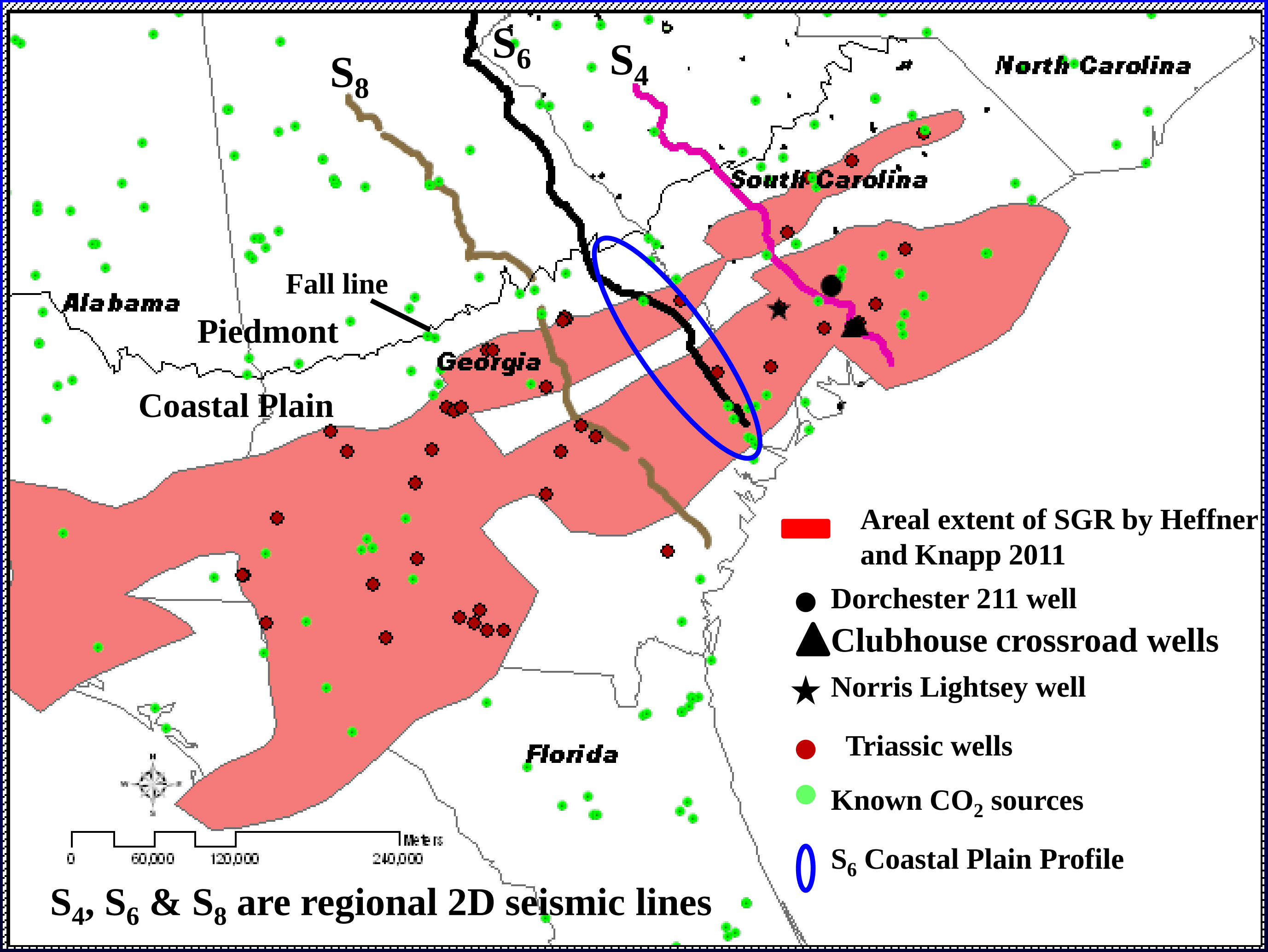
Schematic Cross section of the South Georgia Rift

Jurassic/Triassic formations are buried beneath the Coastal Plain



Philpotts and Martello, 1986, McBride 1991, Oh et al, 1995 and Holbrook and Kelemen, 1993

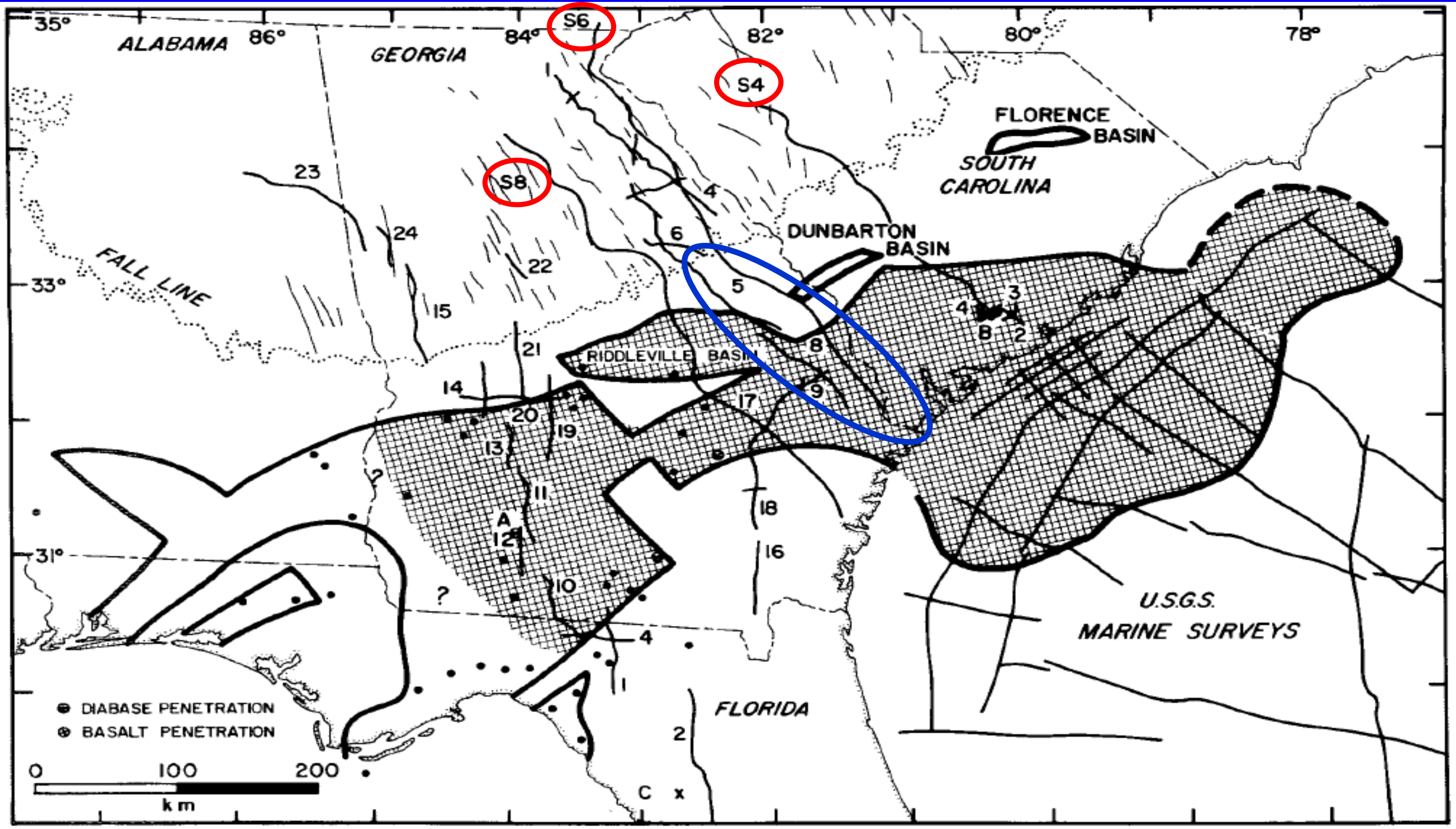
South Georgia Rift Basin



Motivation

- Strategic importance of SEISDATA6 Coastal Plain profile
  - Previous work done in relation to 1886 Charleston earthquake (Behrendt, 1986)
  - Covers Triassic basin sediments that are targets for CO_2 site characterization study
  - Falls within area postulated to be covered by “J” reflector

Motivation



Study area (in blue circle) falls within postulated areal coverage of "J" reflector (McBride et al 1989)

Motivation

- Lateral extent of the 'J' reflector still remains unknown
- Knowing whether or not the 'J' reflector extends to the study area is key to evaluating its regional significance to serve as a CO_2 reservoir seal

Objectives

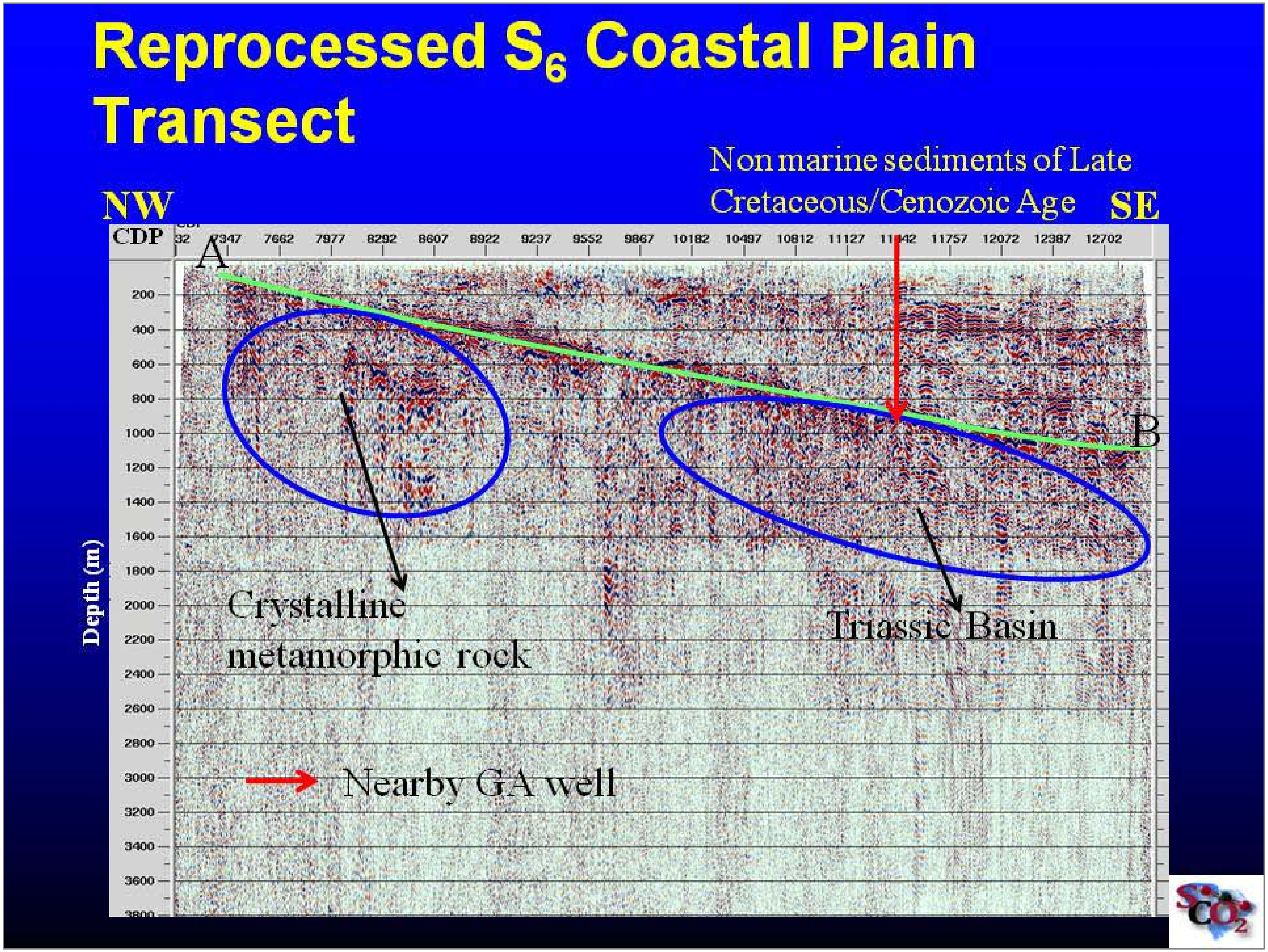
- Identify and Interpret subsurface reflectors to delineate
  - Coastal plain
  - Underlying Triassic/Jurassic sediments
- Evaluate regional significance of the ‘J’ basalt
- Implication for CO_2 sequestration

Methods of Study

1. Adaptive seismic imaging of S_6 Coastal Plain profile
2. Interpretation of depth-converted seismic section
3. Analysis of well logs to substantiate interpretations
4. Construct a geologic model of the study area

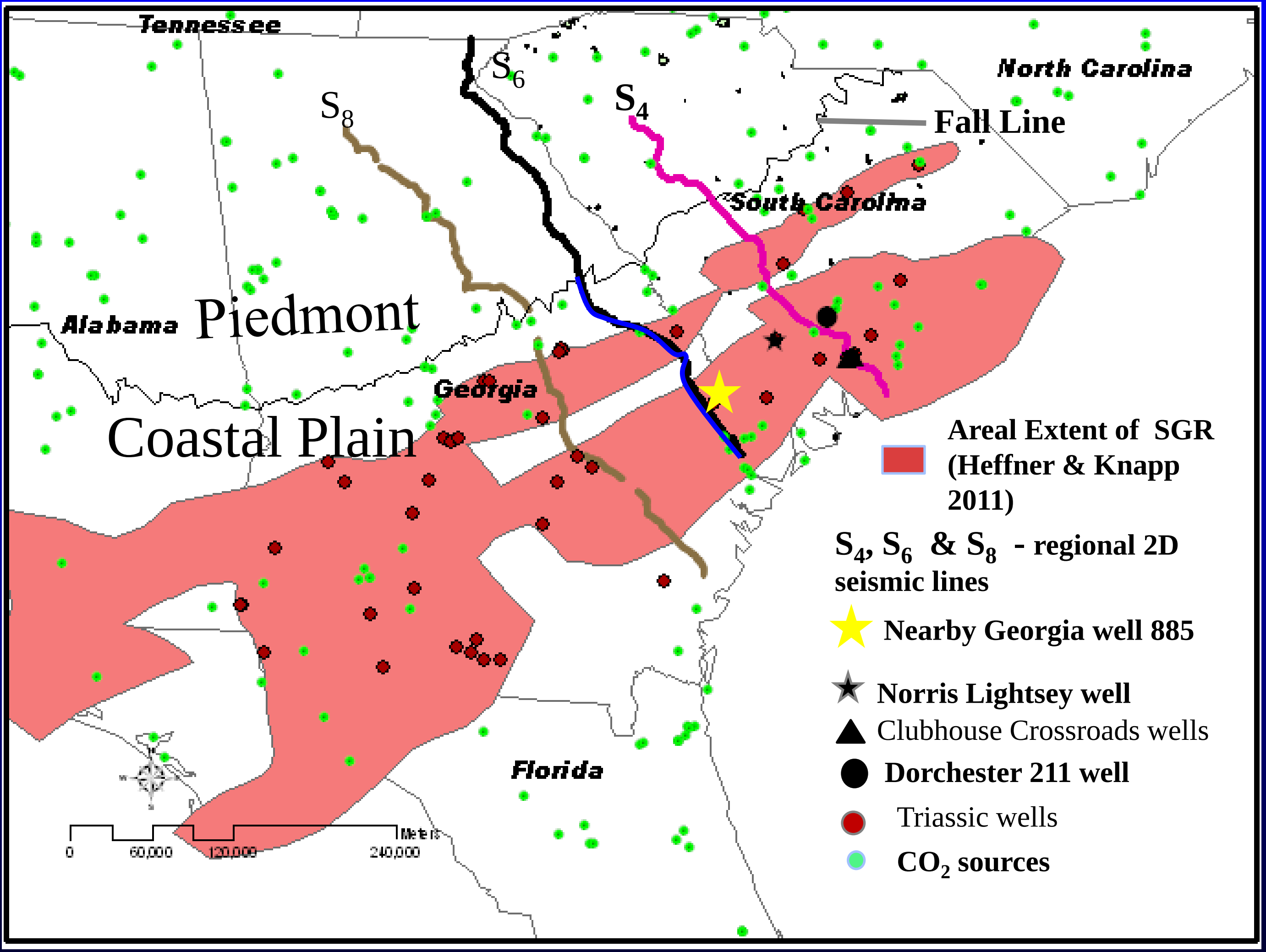
Adaptive Seismic Imaging Workflow

1. Uncorrelated shot gathers
2. Vibroseis Correlation
3. Geometry
4. Attenuation of Noisy Traces
5. True Amplitude Recovery
6. Elevation statics
7. Deconvolution
8. Residual Statics
9. Normal Moveout
10. Common Mid Point Stack
11. Migration
12. Depth conversion

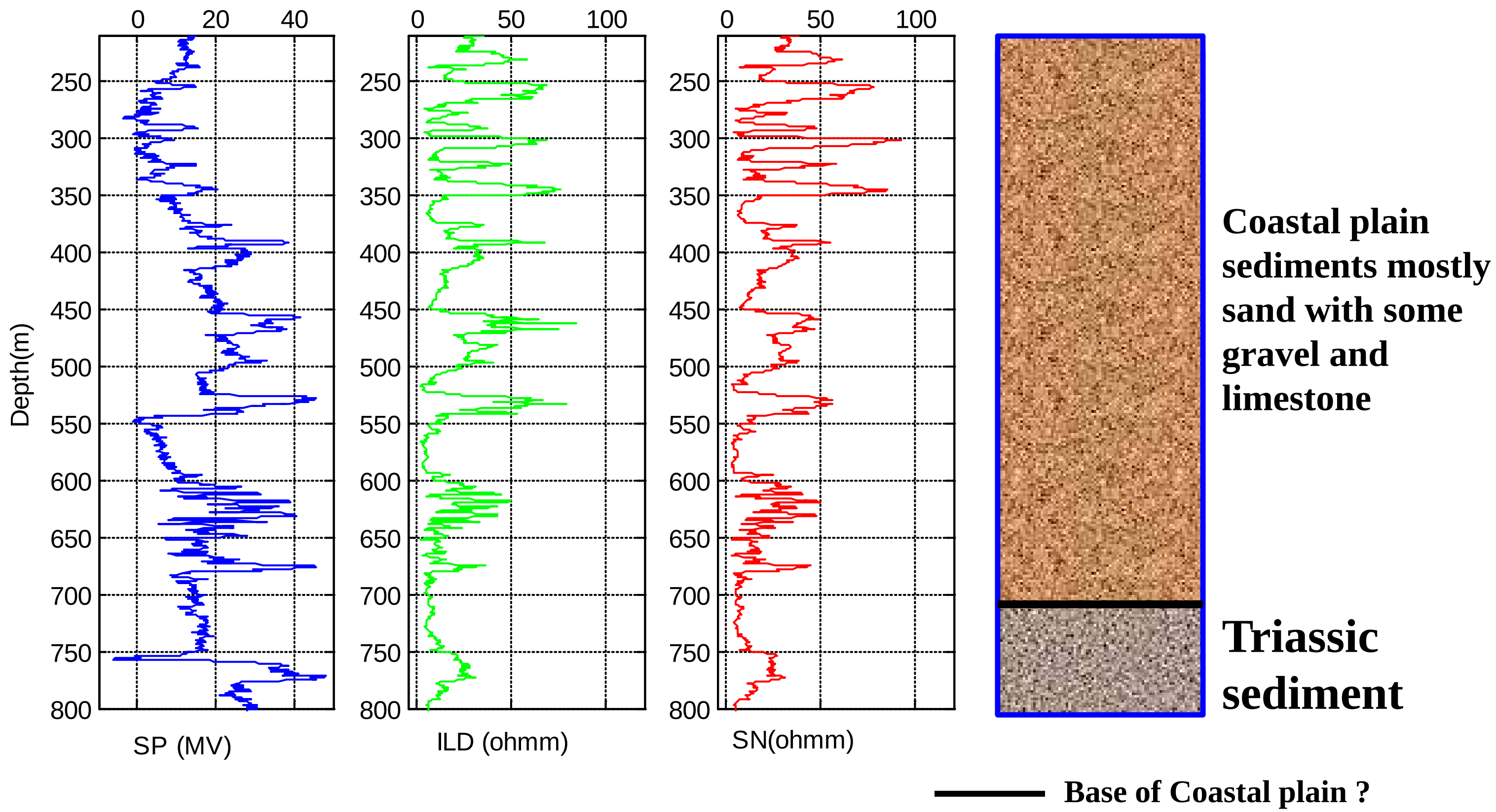


AB is a NW-SE dipping reflector had previously been interpreted as the "J" horizon (McBride et al. 1989 and Behrendt, 1986)

Location of Nearby GA Well



Analysis of Nearby Georgia Well

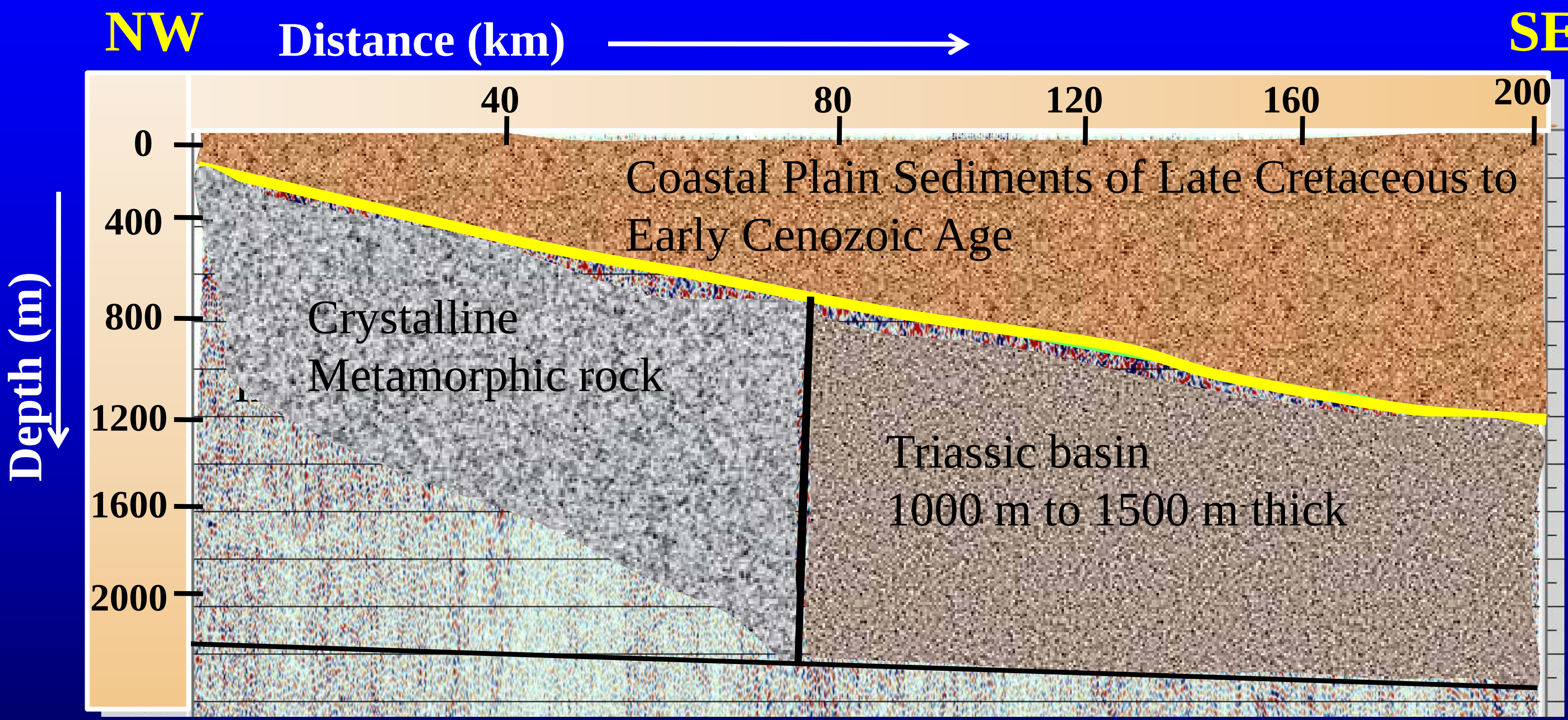


No 'J' basalt

Summary of Information from Other Georgia Wells

Georgia (GA) Wells	Distance from S_6 Profile	Total Depth (m)	Key Observations	Evidence of Triassic unconformity	Evidence of mafic igneous rock
GA 3353	12 miles from CDP 9569 – CDP 9627	1,162	Red beds mixed with basic intrusive at 368 m	Yes at 359 m	Yes, but very, very thin layer at 368 m
GA 3441	25 miles from CDP 8121 – CDP 8312	1,723	Penetrated mostly sedimentary rocks	Yes at 335 m	Yes, but very, very thin layer at 1,707 m
GA 3447	27 miles from CDP 8298 – CDP 8393	2,867	Metamorphic rock from 2538 m to 2867 m (Schist and Quartzite)	Yes at 337 m	No

Generalized NW-SE Geologic Model



Base of Coastal Plain is a:

1. Southeast ward thickening wedge of poorly consolidated sediments
2. Sub-Cretaceous unconformity above Triassic sediments and/or metamorphic rock (Snipes et al 1993)

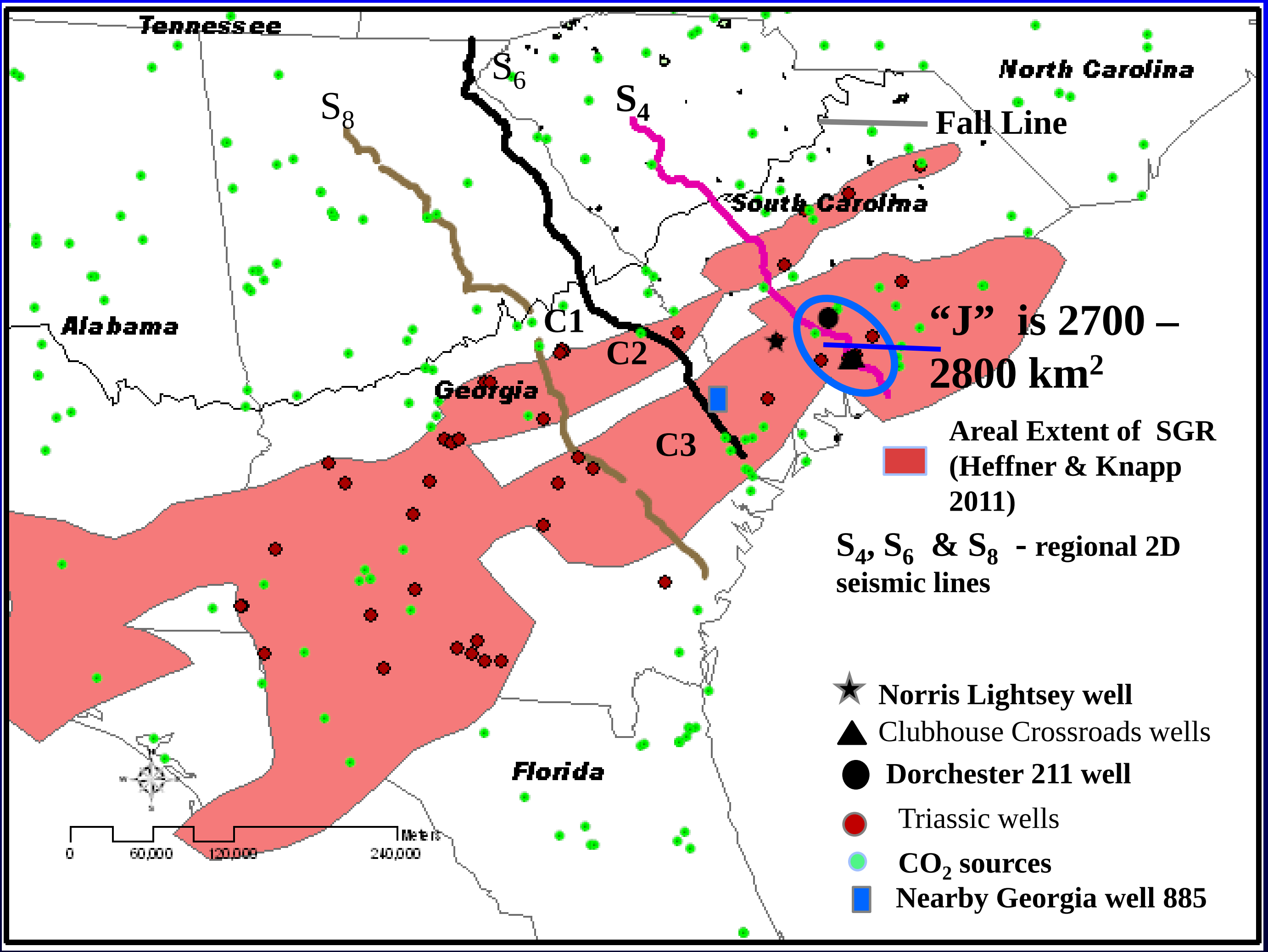
‘J’ Reflector Re-Interpreted

- No ‘J’ Reflector in the study area
- Observed topmost reflector coincides with the base of Coastal Plain
- Results corroborated by well data
- Geologic model consistent with known geology of buried Triassic basin (Marine, 1974)

How Significant is 'J' Reflector?

- Geographical extent throughout SGR
- Ability to serve as a regional seal for CO_2 storage
- Recognition as a distinct geologic marker in the last 25 years
- Understanding regional tectonics

How Significant is ‘J’ Reflector?



Blue circle: Onshore geographical area covered by ‘J’ Reflector

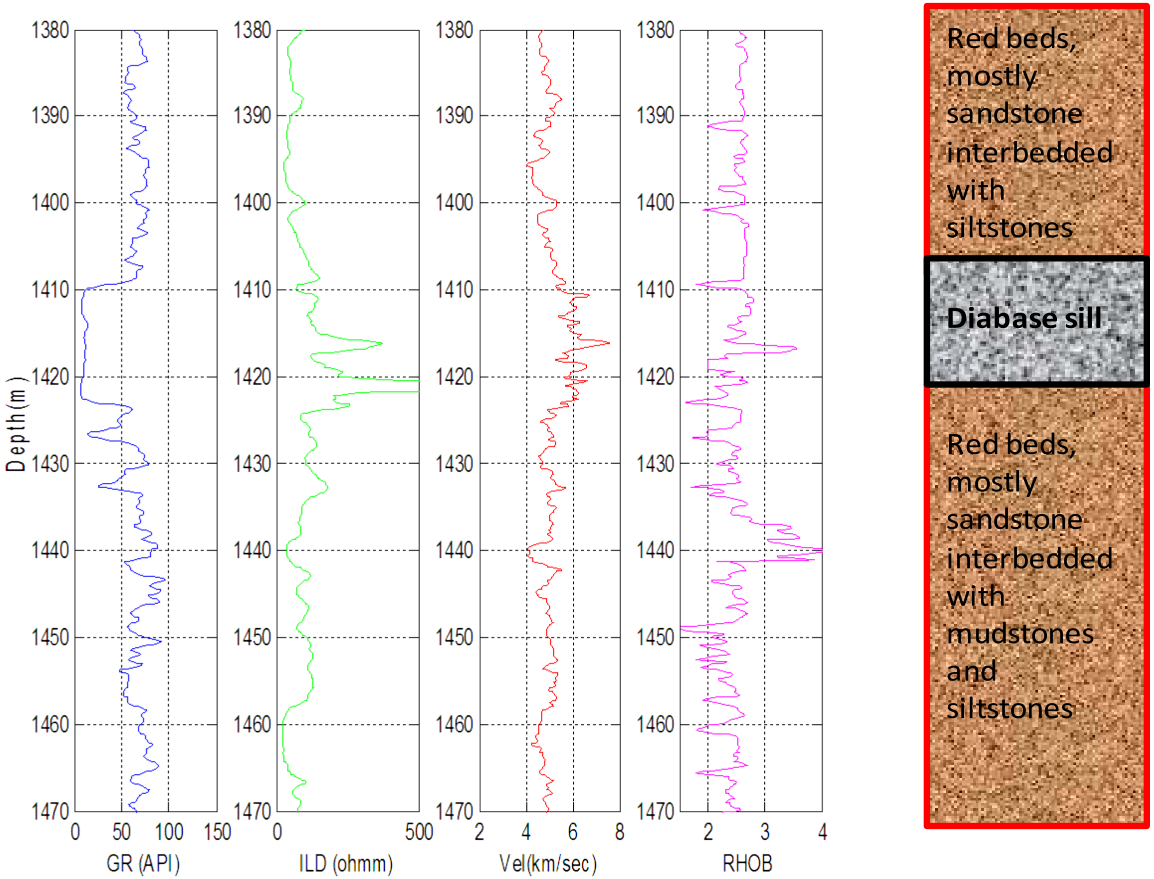
How Significant is the ‘J’ Reflector?

- “J’ reflector does not appear in the study area contrary to existing paradigm
- ‘J’ appears to be more areally restrictive than previous interpretations
- Areal extent 2, 700 – 2, 800 km^2 (onshore)

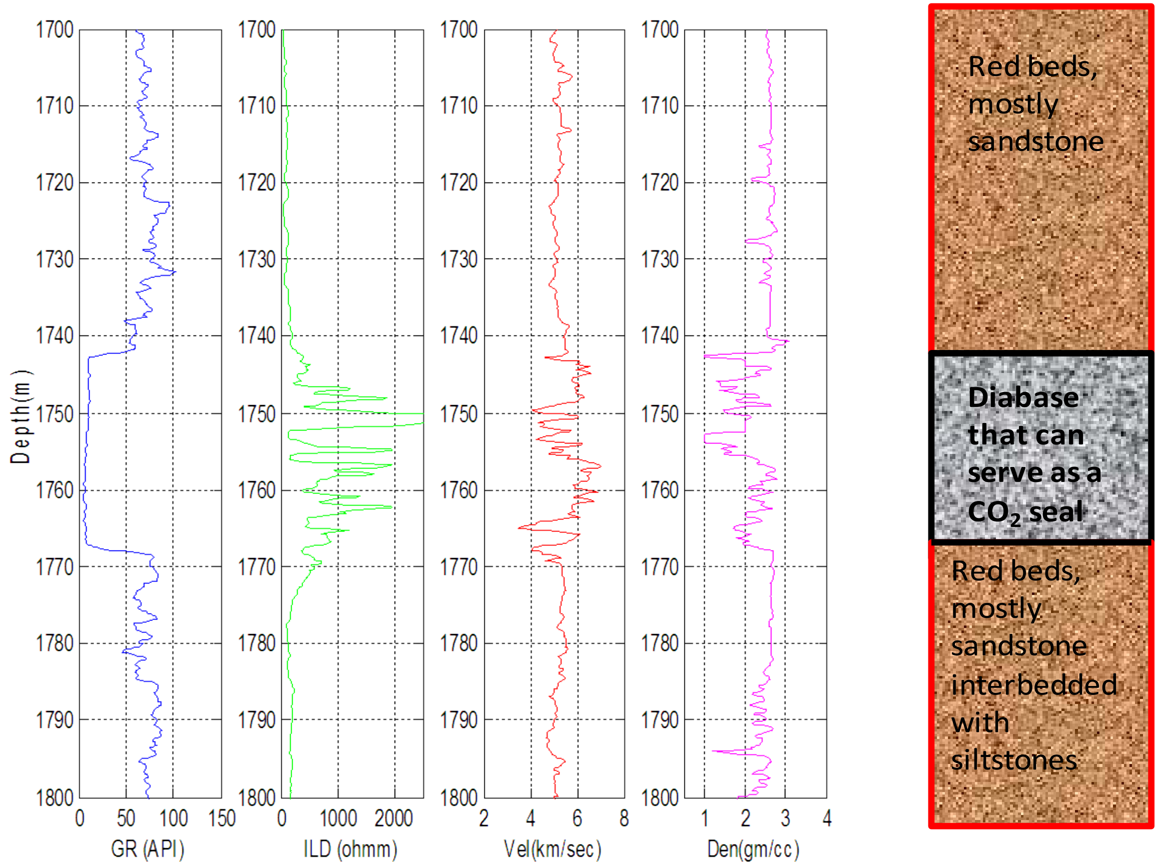
Implications for 'J' Restriction

- May suggest uplift or erosion possibly associated with fault reactivation
- Need for improved understanding of the lateral extent of the 'J' if used as a CO_2 reservoir seal
- Absence does not preclude subsurface CO_2 storage in the SGR
  - Presence of diabase that can serve as a seal

Norris Lightsey Well



Norris Lightsey Well



Conclusions

- Our new results substantiated by well data have redefined the significance of the “J” Basalt reflector
- The “J” reflector within study area appears to be in fact base of the Coastal Plain
- This is a sub-Cretaceous unconformity that separates poorly consolidated sediments from underlying Triassic sediments

Conclusions

- Our new interpretations suggest absence of "J" Basalt in the study area
- Absence implies
  - More areally restrictive distribution of "J" Basalt in SGR than previous interpretations
  - uplift or erosion possibly associated with fault reactivation
- Absence of "J" Basalt does not preclude subsurface CO_2 storage within SGR
- Diabase sills can serve as CO_2 seals

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