Site Characterization for CO_2 Storage from Coal-Fired Power Facilities in the Black Warrior Basin of Alabama

Peter E. Clark, Andrew M. Goodliffe, and Eric S. Carlson, University of Alabama

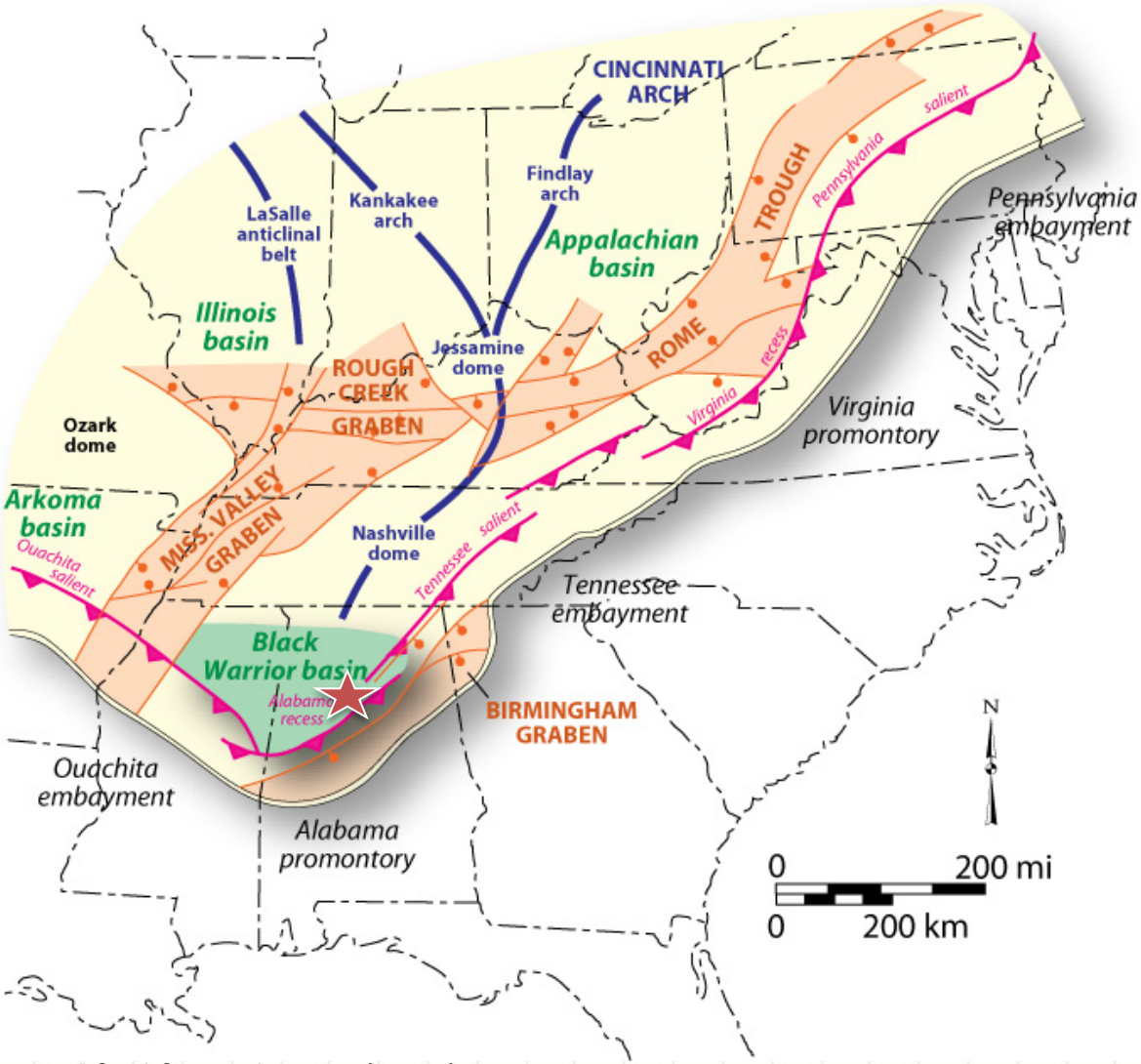
Jack C. Pashin, Geological Survey of Alabama

Mason Tomson, Rice University

DE-FE0001910

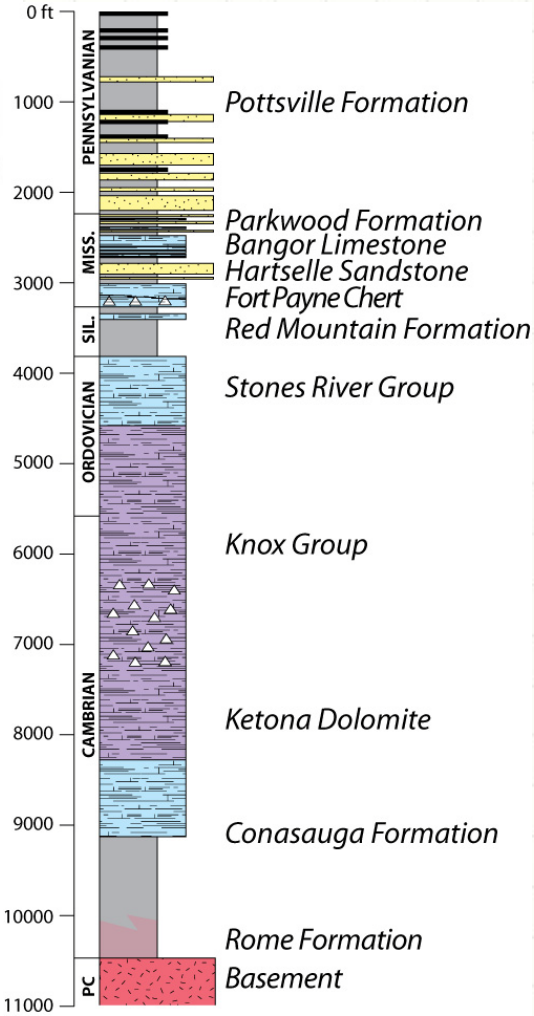
REGIONAL SETTING

Tectonic Framework



modified from Thomas (1988)

Stratigraphy



Pashin (2011)

WILLIAM CRAWFORD GORGAS STEAM PLANT

PROJECT TEAM

The University of Alabama (Lead)

Peter Clark, Eric Carlson, Andrew Goodliffe

Geological Survey of Alabama

Jack Pashin

Rice University

Mason Tomson

University of Alabama at Birmingham

Pete Walsh

Southern Company, Alabama Power

Richard Esposito

Schlumberger Carbon Services

Micro-g Lacoste

SECARB

OUTLINE

- Project Overview
- Geological Analysis
- Geophysics
- Simulation

PROJECT GOALS

Assess the risks associated with geologic carbon storage in the Black Warrior basin.

Develop a regional plan and BPM for carbon sequestration.

Analyze the CO_2 storage capacity and injectivity of stacked saline formations in the Cambrian-Pennsylvanian section of the Black Warrior basin.

PROJECT OBJECTIVES

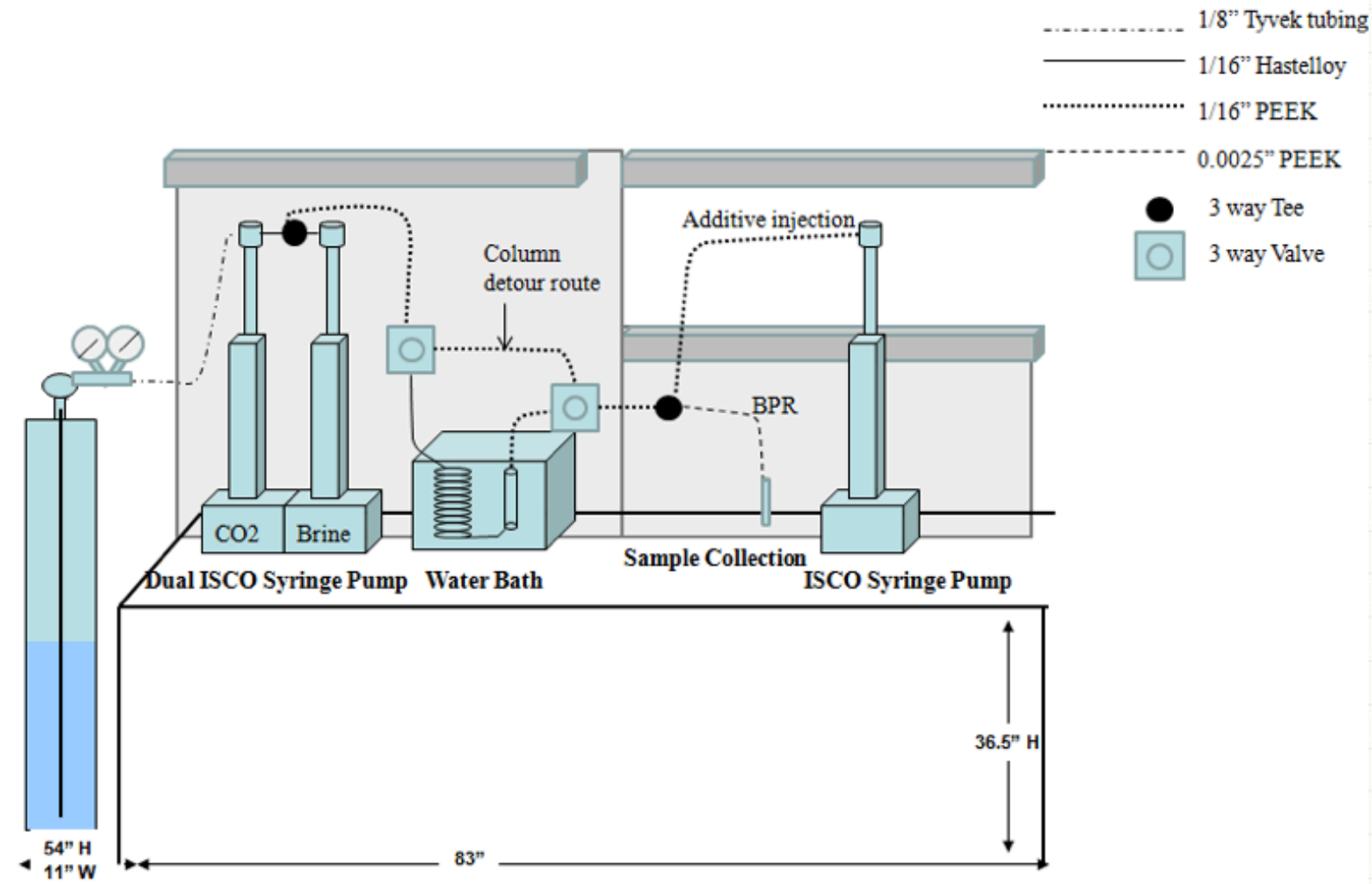
- Assess saline reservoirs, O&G reservoirs
- Shoot 2-D seismic profiles
- Drill geologic test well at Plant Gorgas
- Core reservoirs and seals
- Quantify reservoir properties
- Analysis of mineralization, dissolution, seals
- Reservoir simulation
- Develop best practices manual
- Leave infrastructure at plant

PROGRESS

- Well has been drilled and completed
  - Struck fresh or nearly fresh water at the top of the Copper Ridge which was the target formation
  - Found oil shows in two other formations
  - All of the standard logs were run as well as two experimental Schlumberger logs
  - Analysis of the data is underway

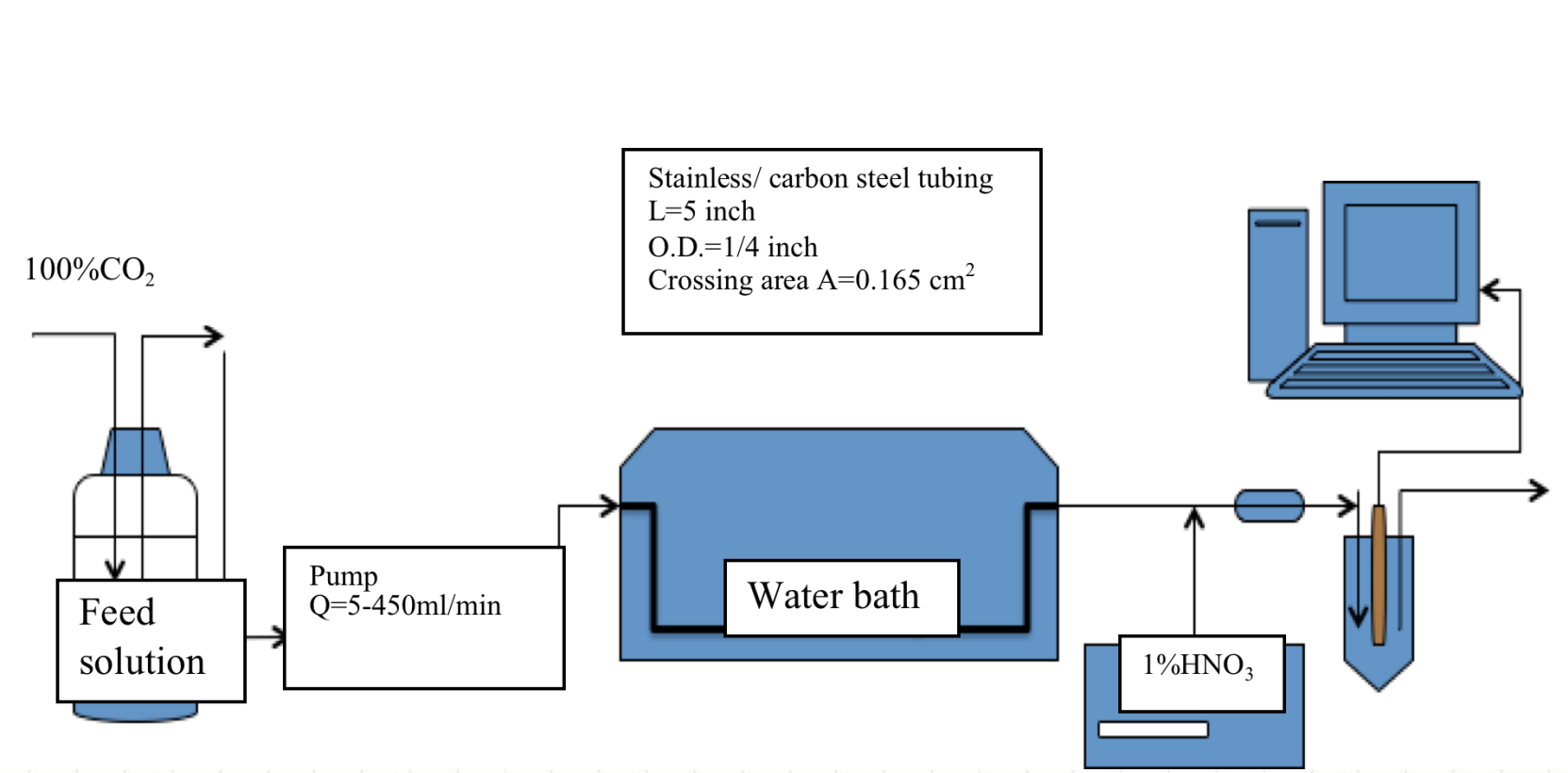
PROGRESS

Mineralization — Dolomite dissolution



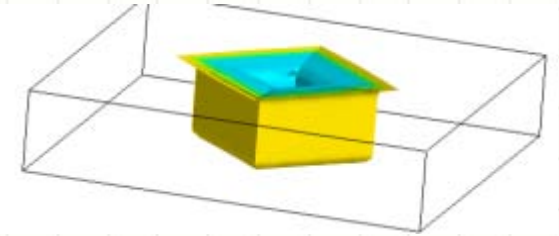
PROGRESS

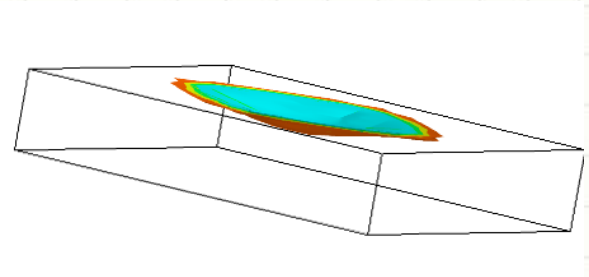
Mineralization Studies — $CaCO_3$ ppt studies



SIMULATION

Simulation Studies





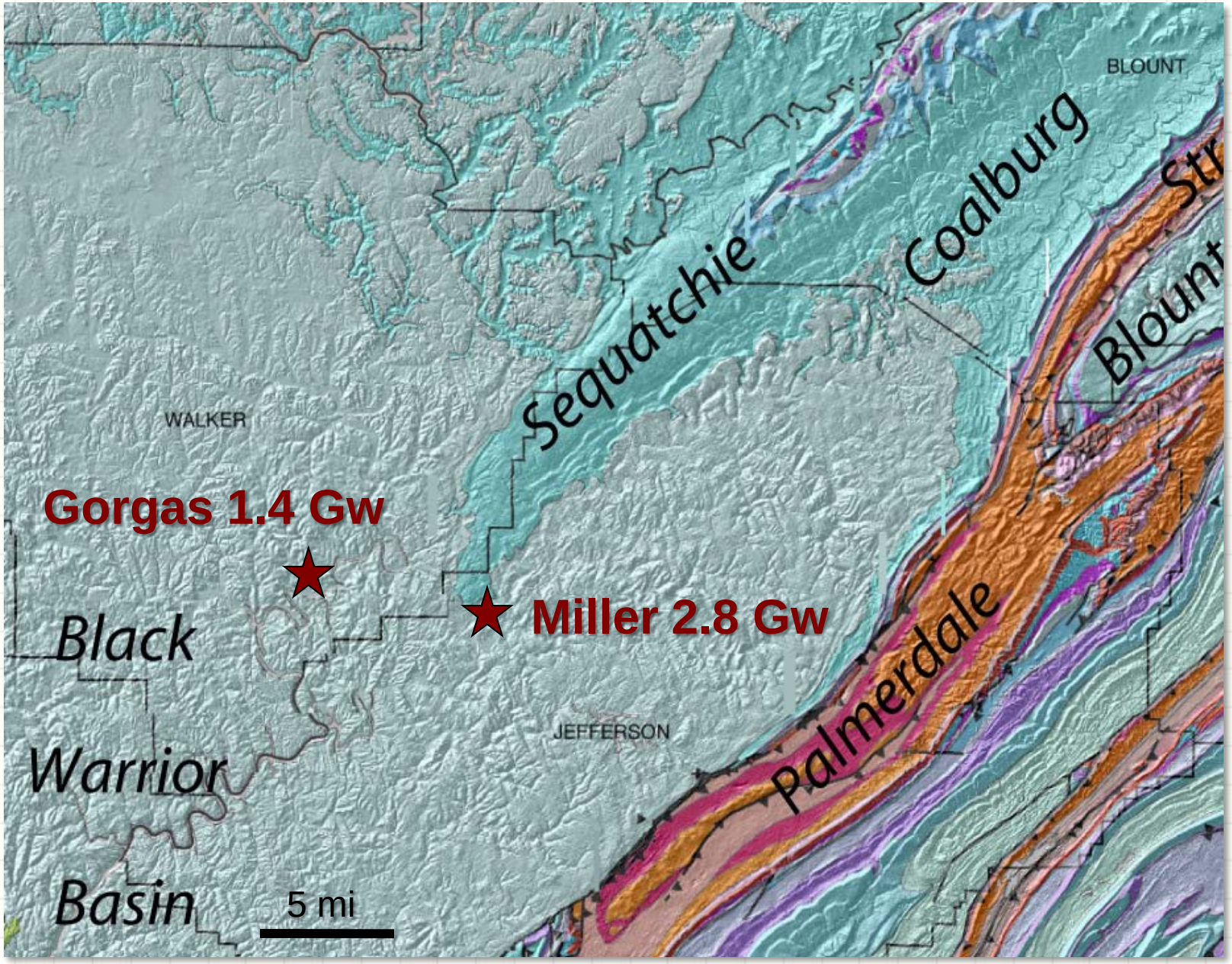
- Have created a new, open-source simulator
- Have developed new CO_2-brine phase behavior correlations which allow explicit calculation of CO_2 concentrations in brine and brine density
- Currently calibrating simulator against some petroleum industry standard cases
- Waiting on geologic models

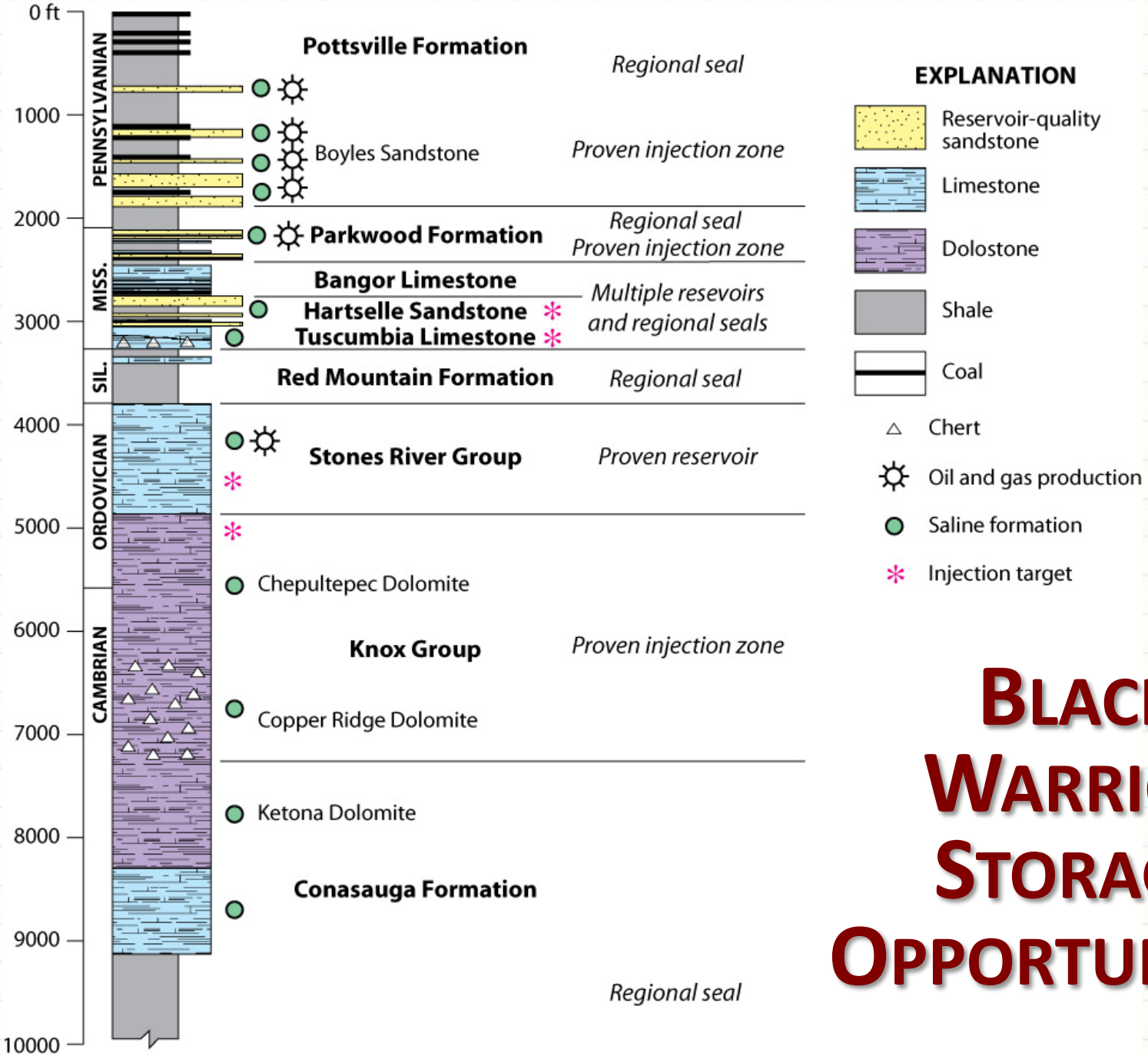
OUTREACH AND EDUCATION

- ✓ Seismic Lunch ‘n Learn
- ✓ RECS 2011
- ✓ Korean delegation
- ✓ Gorgas site visits
- ✓ SECARB-Ed

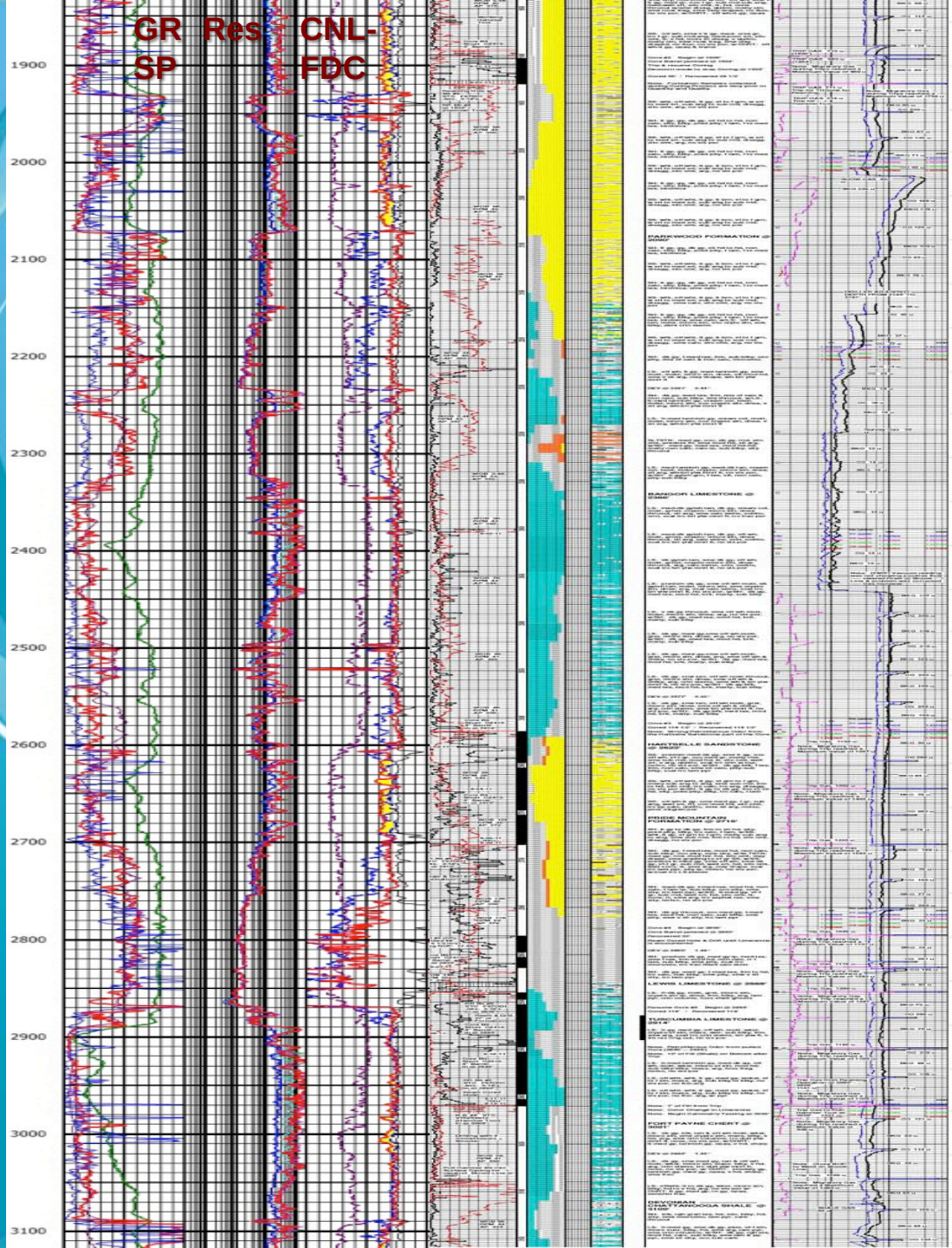
SECARB ED
Southeast Regional Carbon Sequestration Technology Training Program

GEOLOGIC MAP





Black Warrior Storage Opportunities



WELL LOGS

Gorgas #1 borehole

Boyles SS

Gas show

Parkwood Fm.

Bangor LS

Oil show

Hartselle SS

Pride Mtn. Fm.

Tuscumbia LS

Oil show

Chattanooga Sh

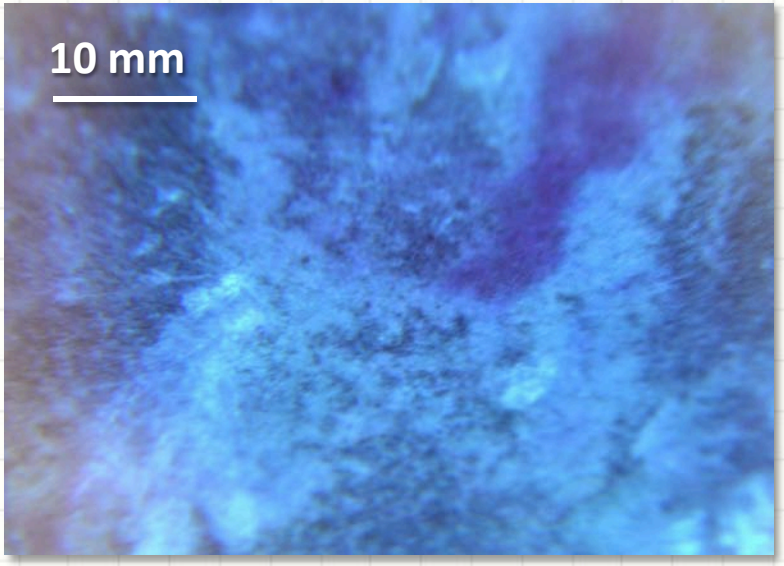
GORGAS #1 CORES

Preparation for analysis

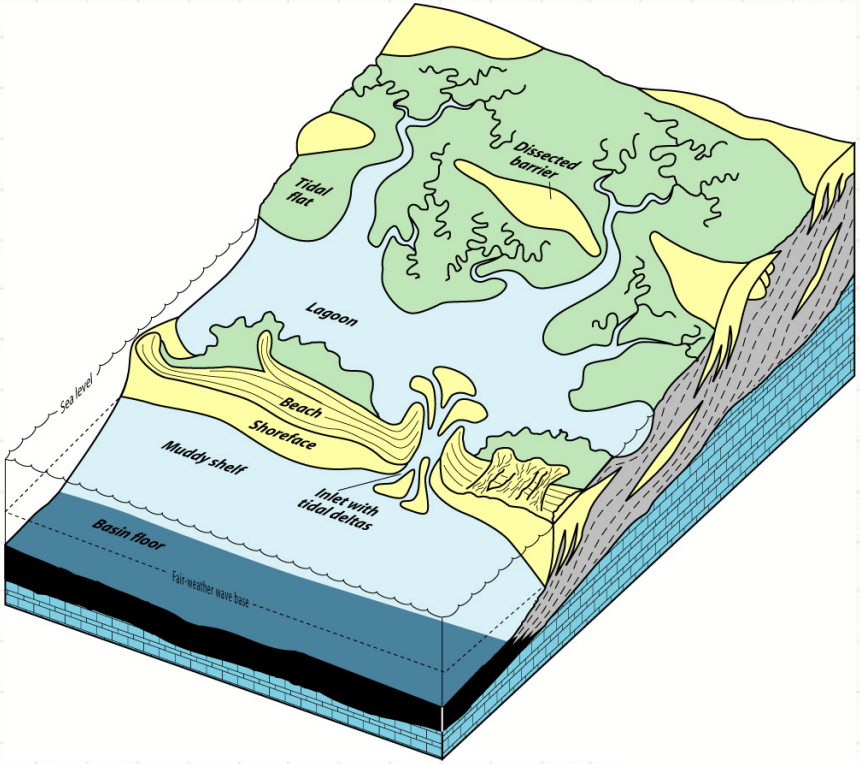
Geological description

CARBONIFEROUS RESERVOIRS

Hartselle SS (fluoroscope)



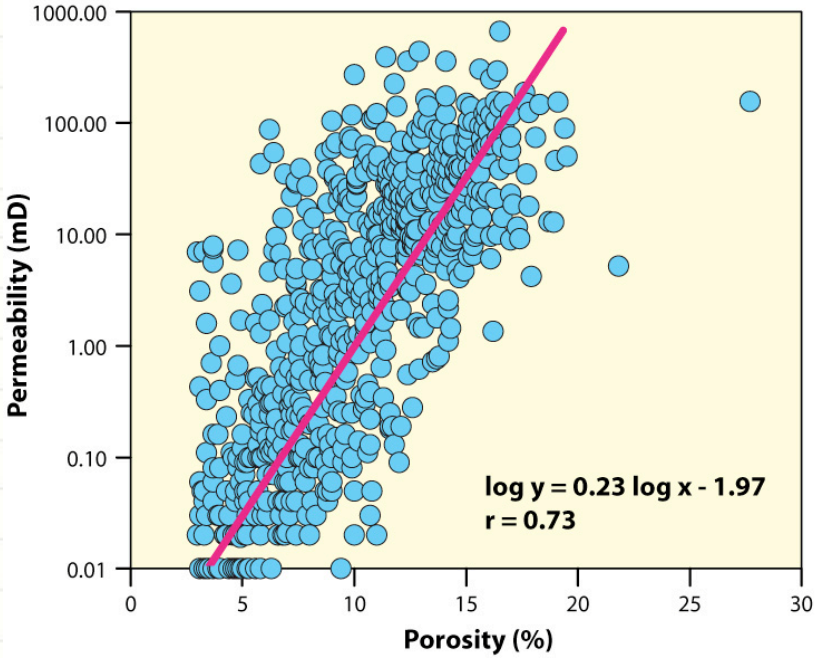
Mississippian Beach-barrier model



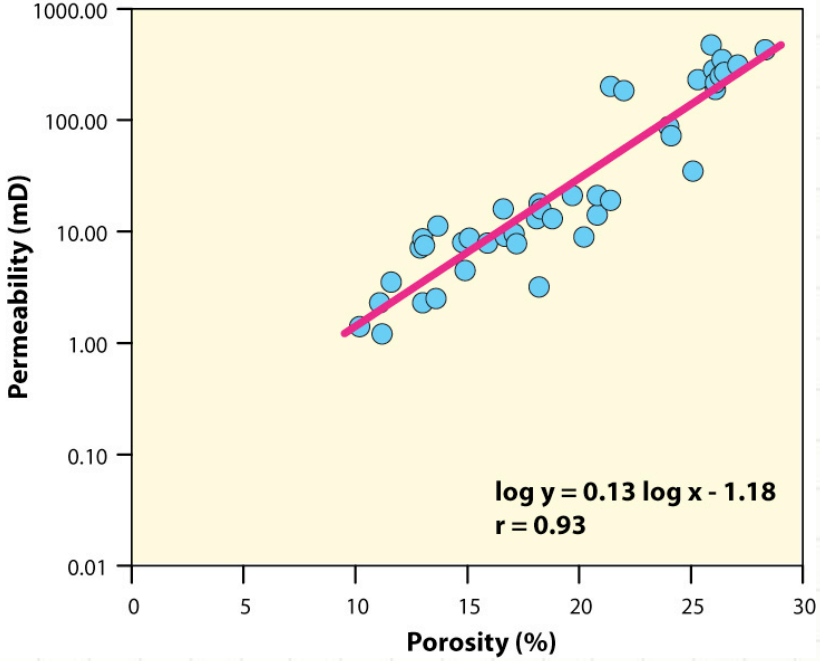
Water beading on Tuscumbia LS

POROSITY, PERMEABILITY

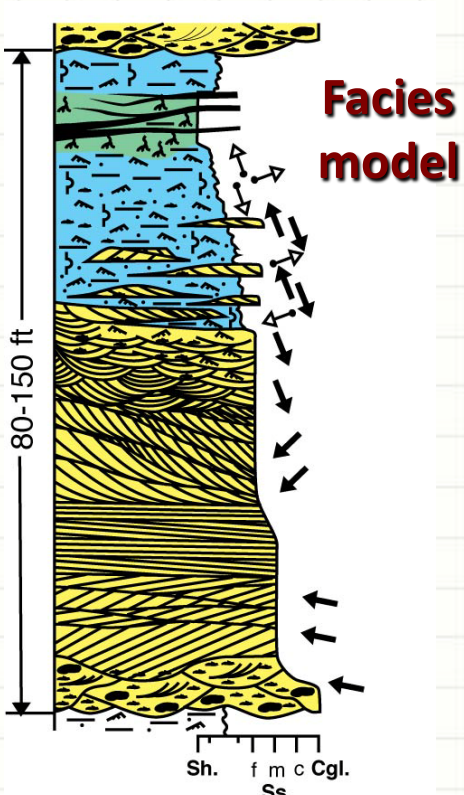
Mississippian



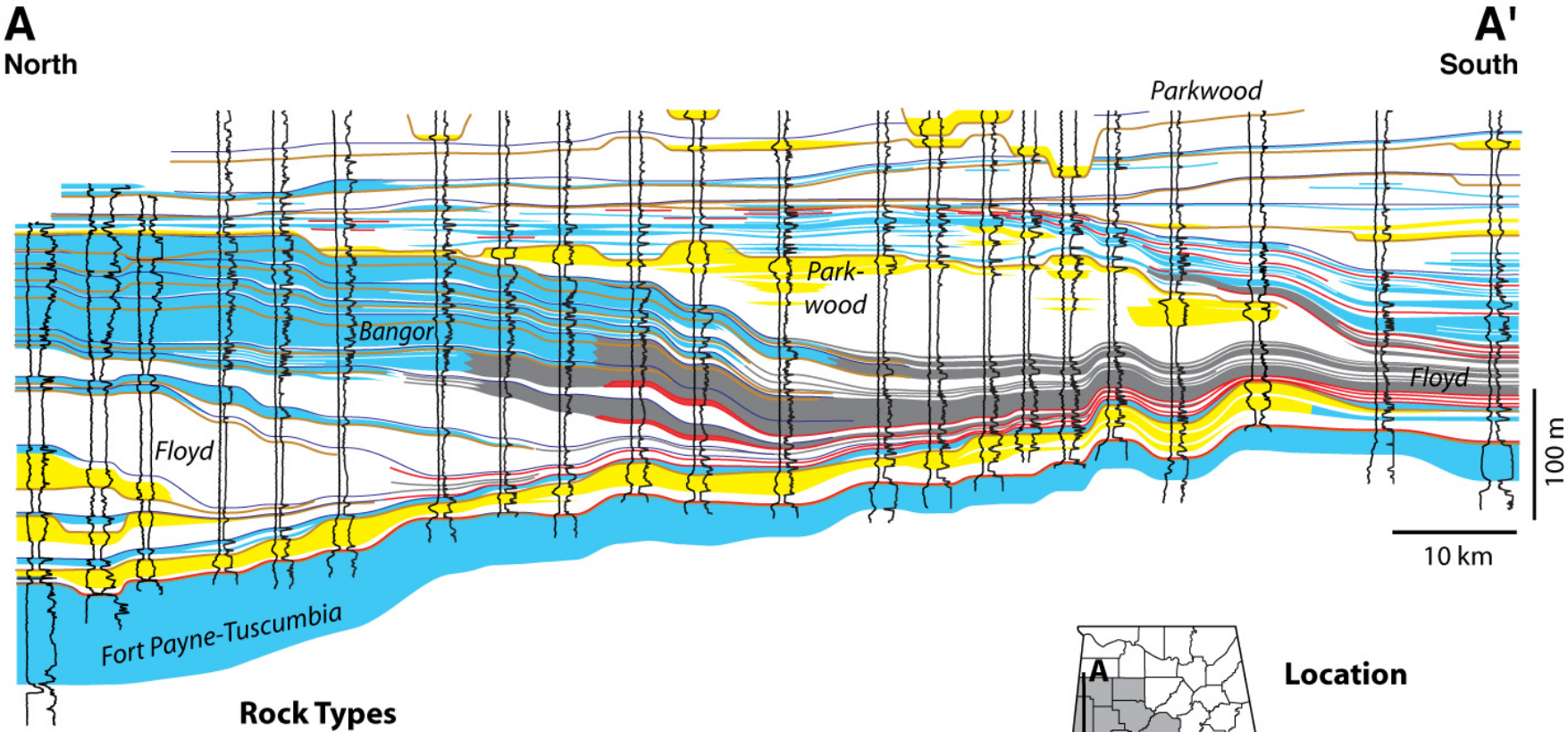
Pottsville



BEACH AND TIDAL DEPOSITS



MISSISSIPPIAN CROSS-SECTION



Rock Types

- Sandstone
- Limestone
- Conductive shale
- Resistive shale
- Radioactive shale

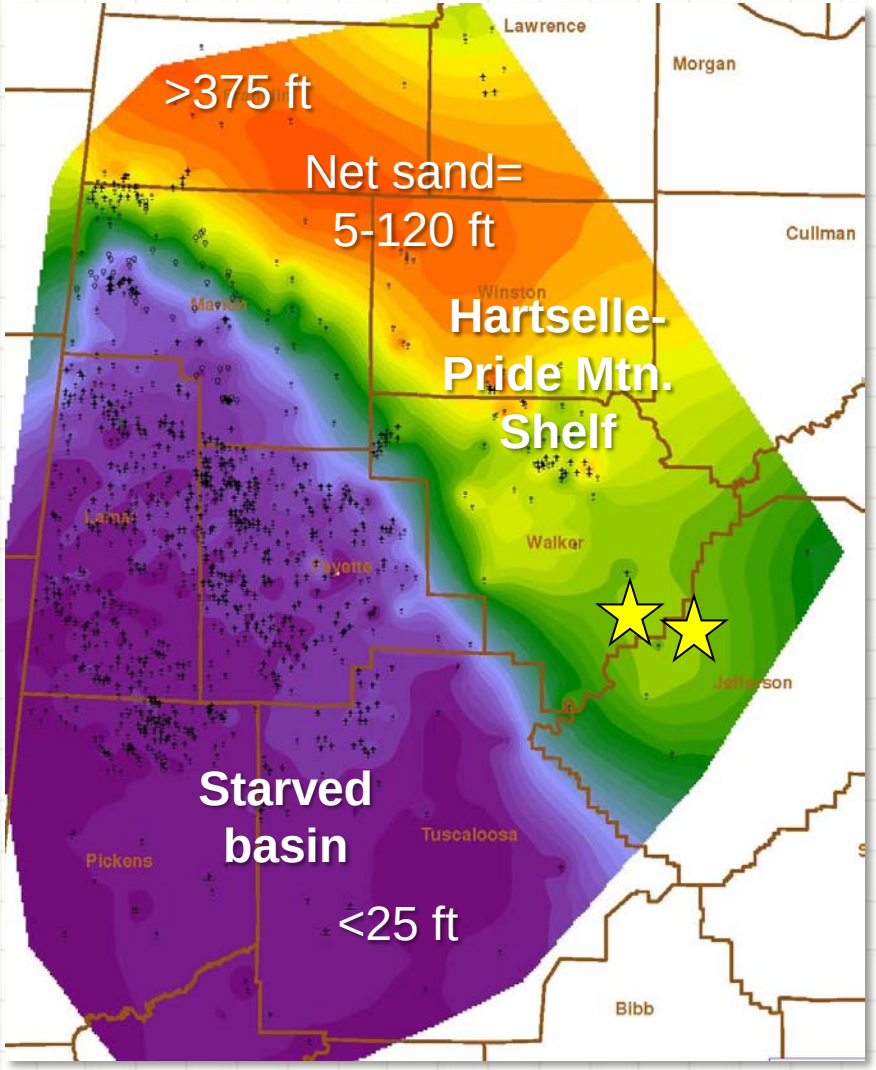
Stratigraphic Markers

- Sequence boundary
- Maximum flooding surface

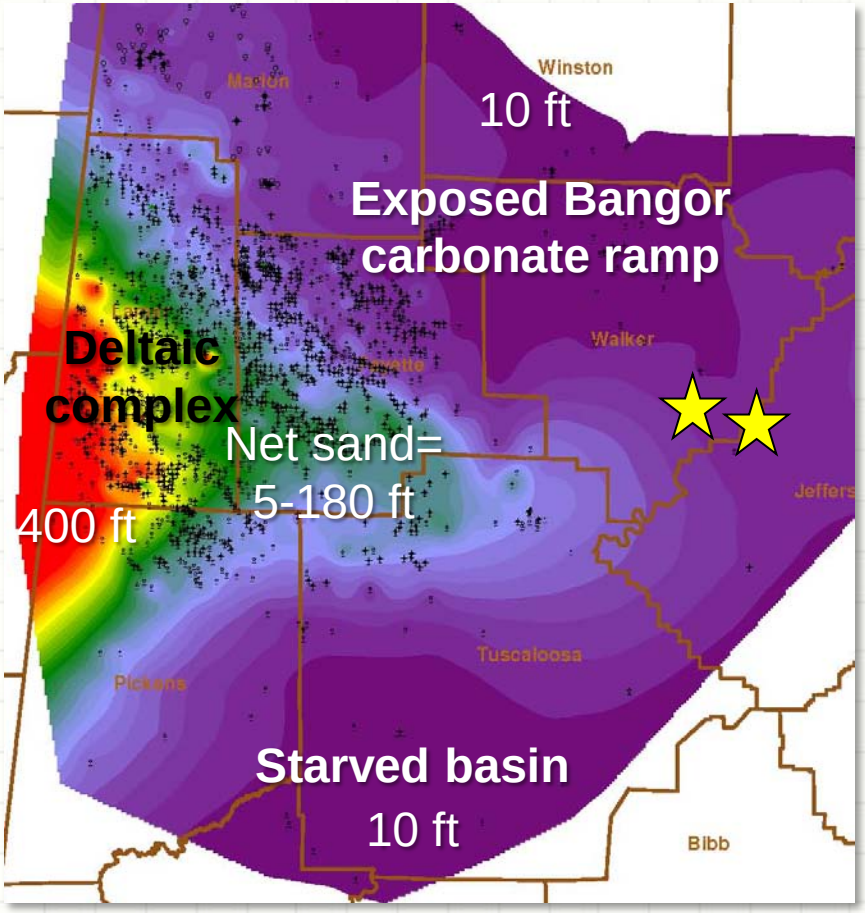
Location

SUBSURFACE MAPS

Pride Mtn.-Hartselle

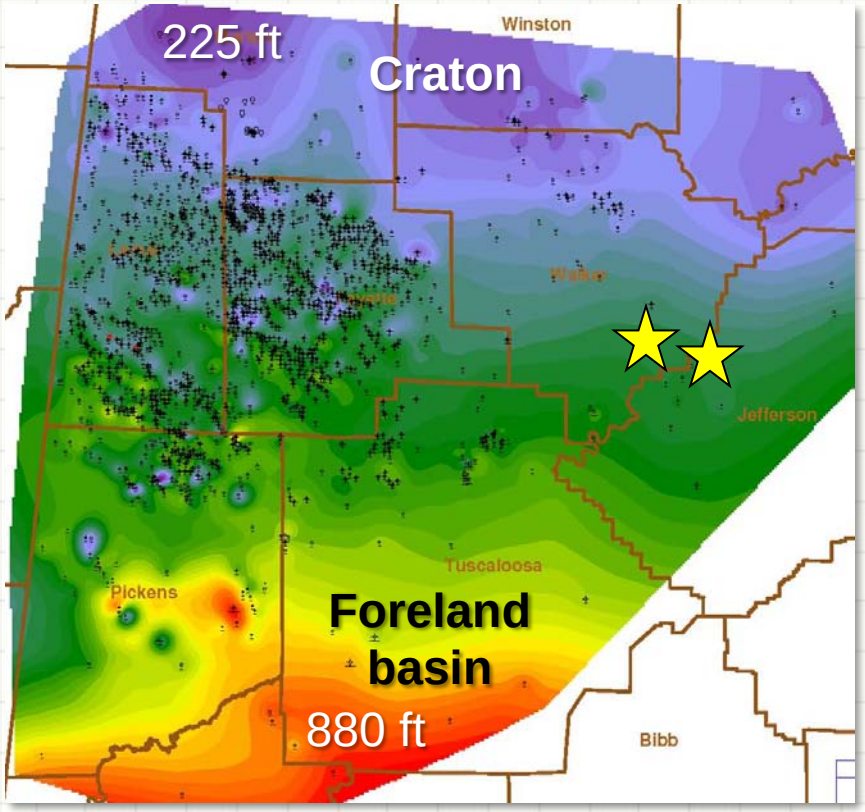


Parkwood Fm.

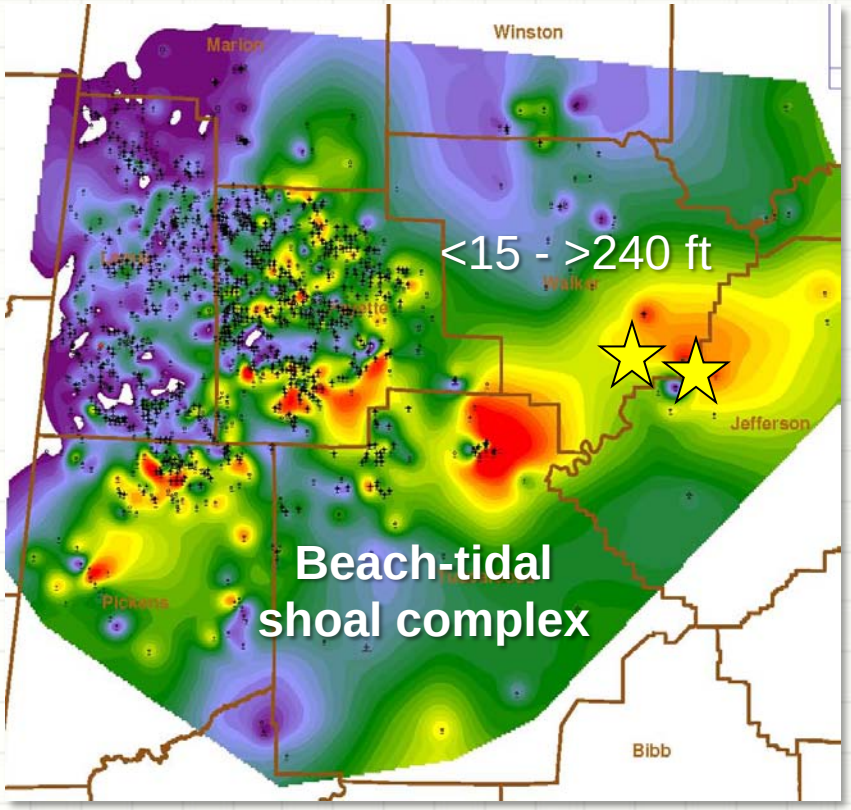


LOWER BOYLES SANDSTONE

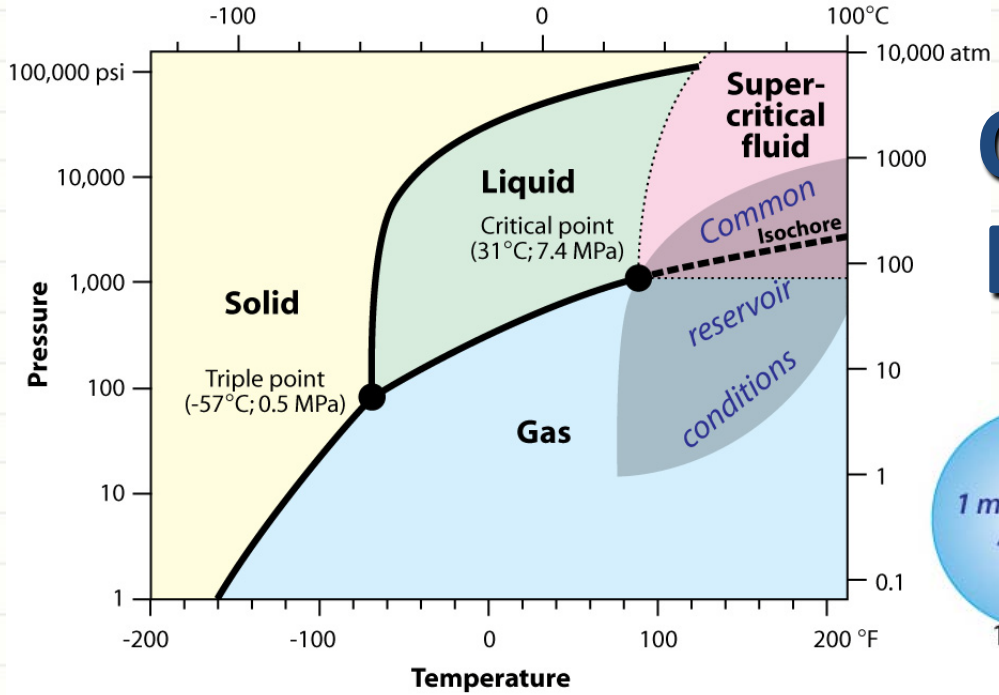
Interval Isopach

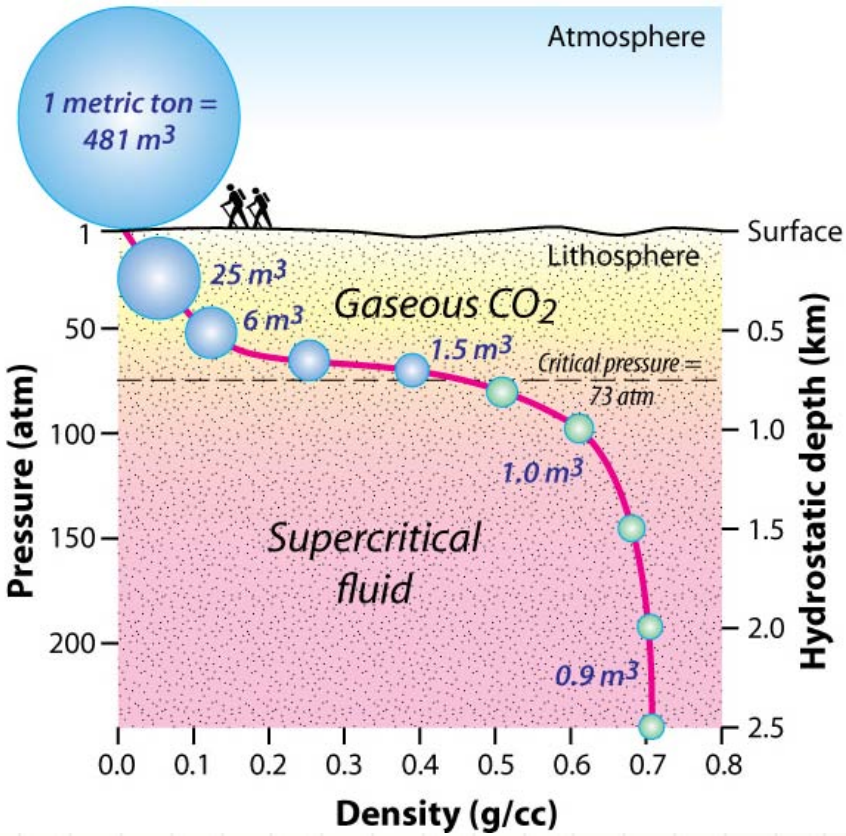


Net porous sandstone

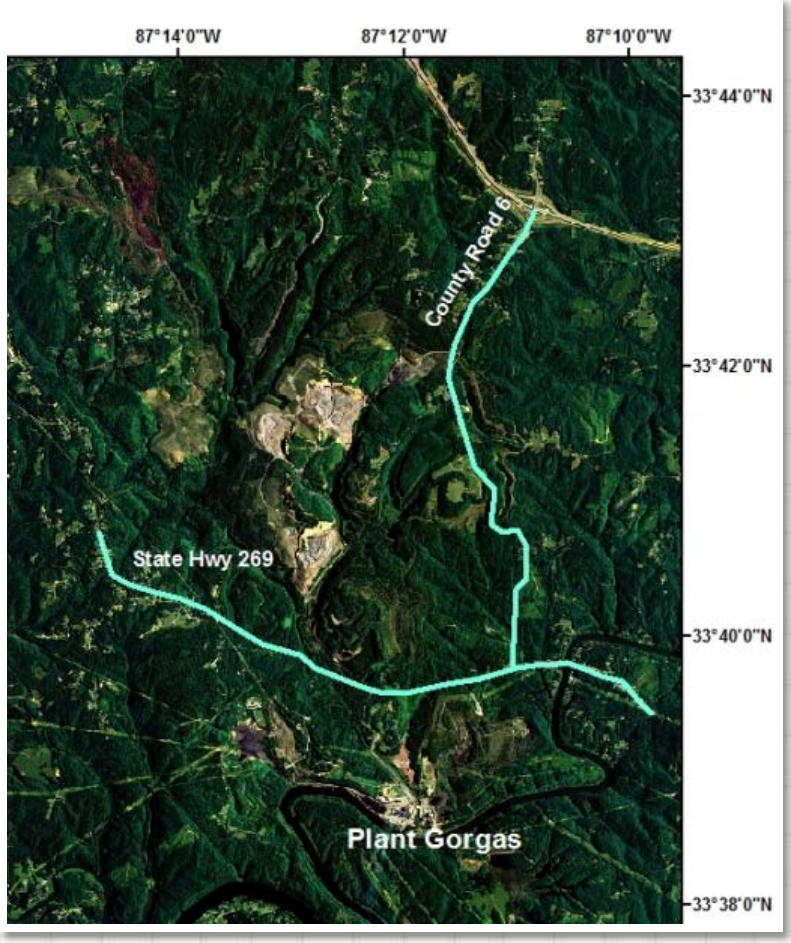


CO_2 PHASE, PVT RELATIONSHIPS





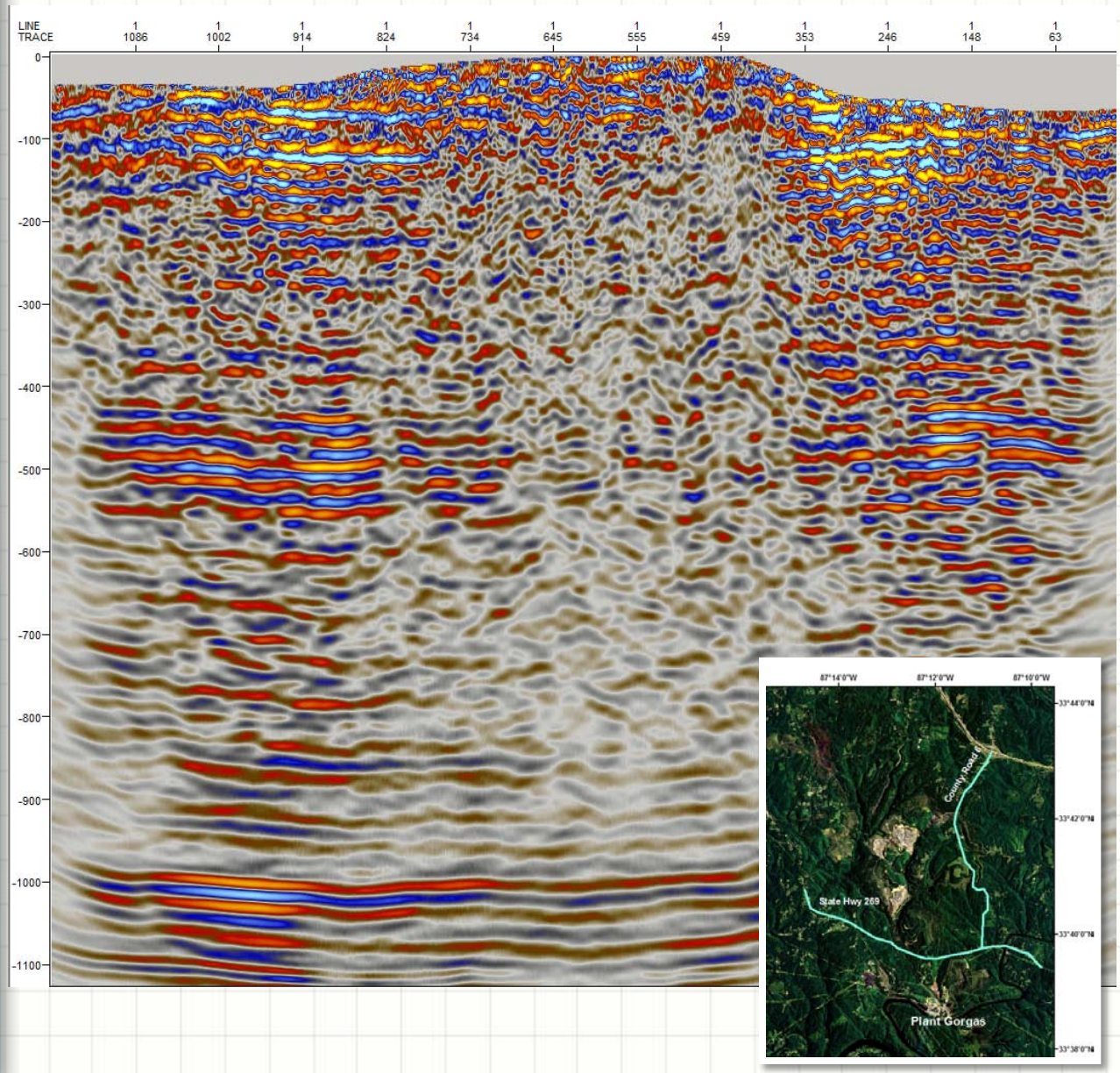
2-D SEISMIC REFLECTION



Survey Parameters:

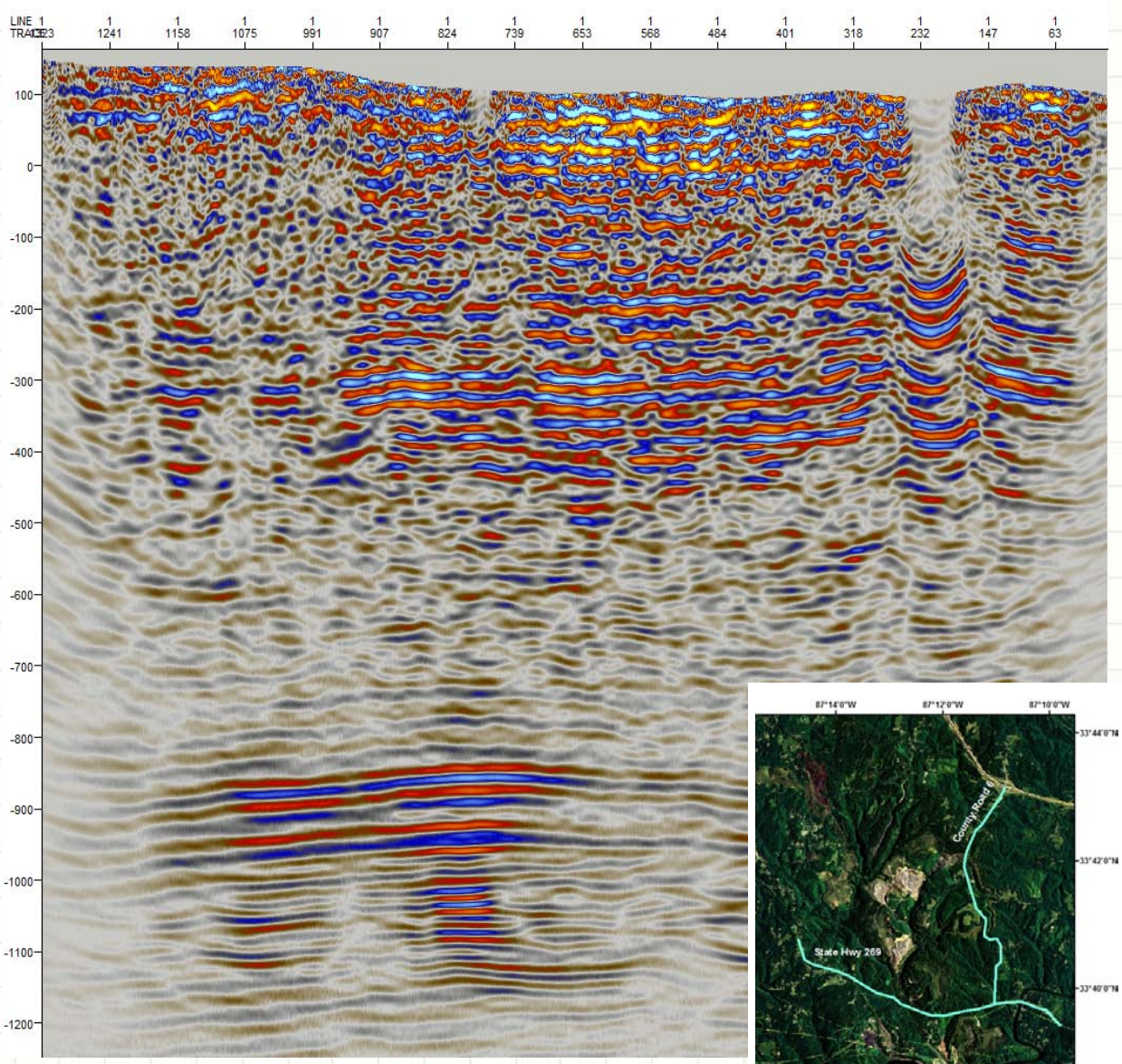
- Two lines five miles long
- 10 foot receiver interval (40 foot group)
- 120 foot shot interval
- Three hemi-44 45,000 lb vibrosis truck
- 6-100 Hz 14 second sweep repeated 4 times at each location
- Record length = 5 seconds
- Sample interval = 2 ms

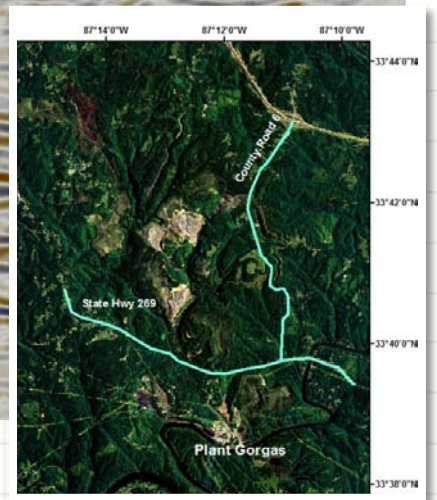
2-D SEISMIC REFLECTION



- Line 101 (N-S): Processed through pre-stack time migration
- Tuscumbia Limestone clearly visible at ~400 ms
- Poorly imaged in center

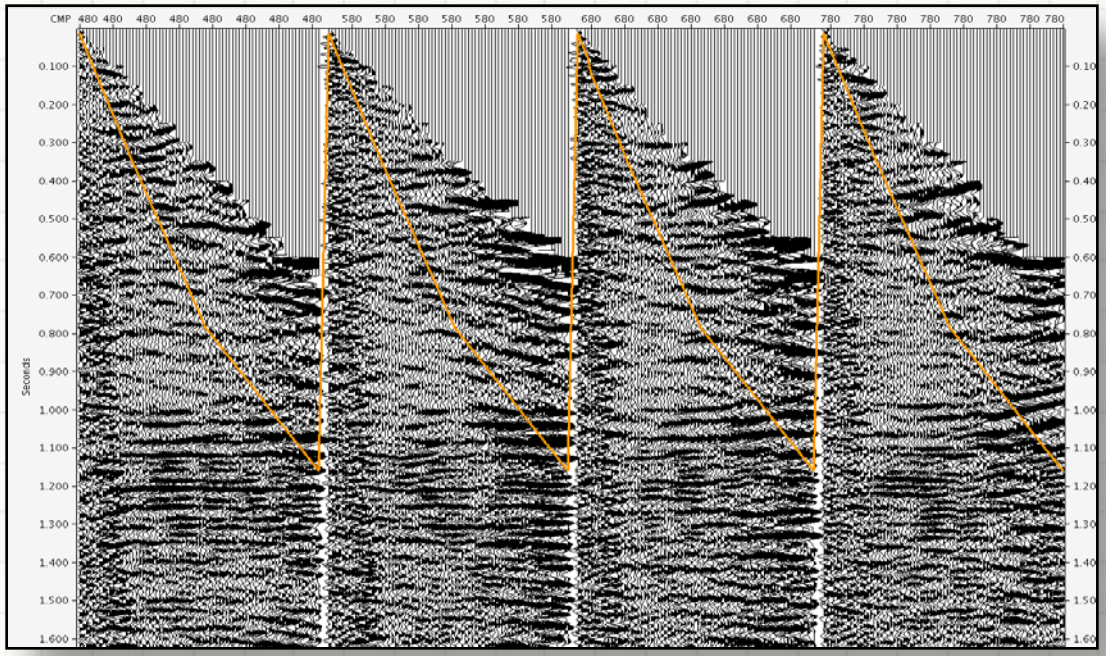
2-D SEISMIC REFLECTION

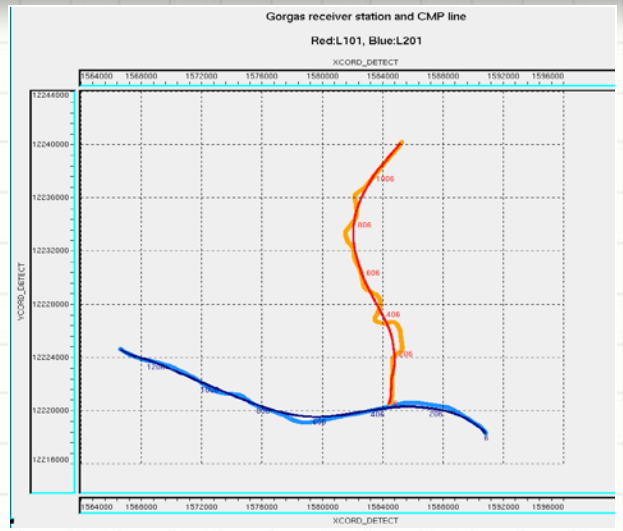




- Line 201 (E-W):
- Processed through pre-stack time migration
- Tuscumbia Limestone clearly visible at ~300 ms
- Excellent Imaging in vicinity of well

2-D SEISMIC REFLECTION



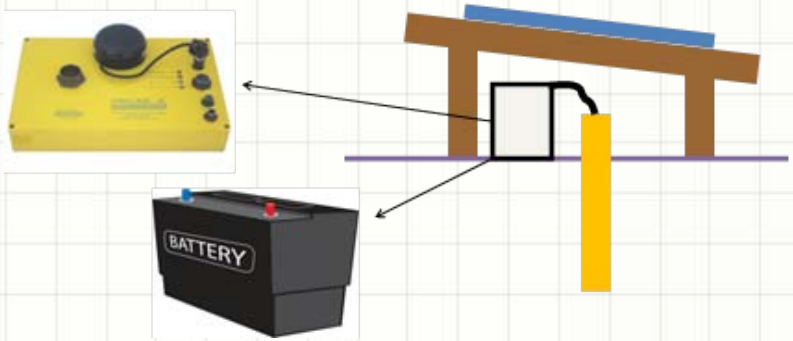


Future Directions for Seismic Reflection Data

- Re-processing to improve mutes
- Re-visit crooked line geometry
- Re-processing as a pseudo 3-D dataset to identify out of plane reflectors
- AVO
- Inversion

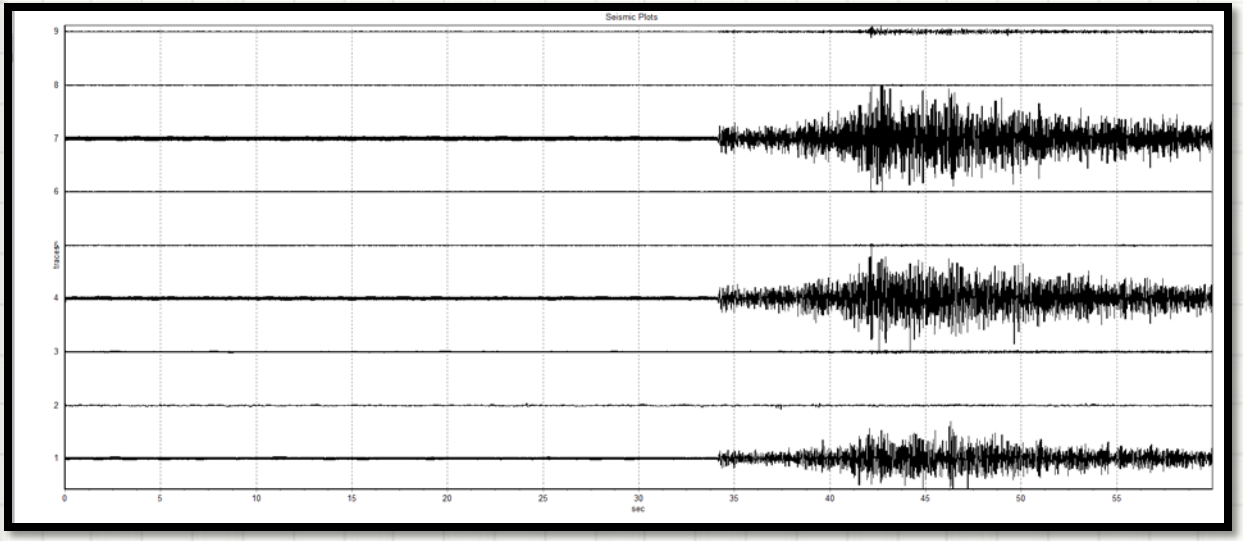
MICROSEISMIC MONITORING

MICROSEISMIC MONITORING

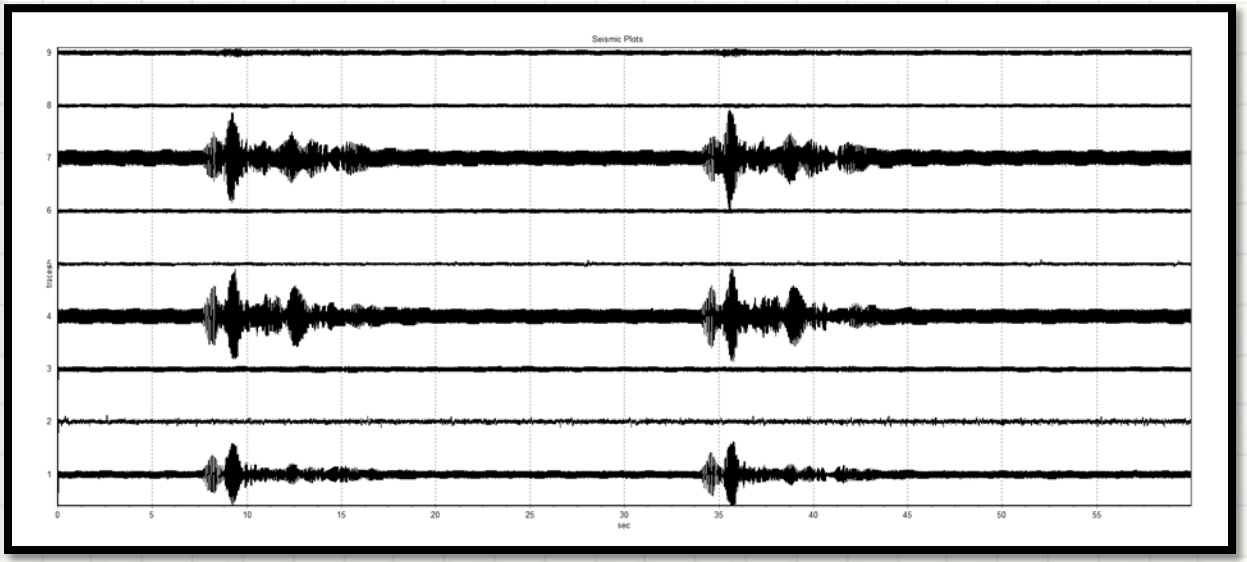


- Pods containing three-component SM45 geophones at 90, 190, and 290 foot depths
- Weight at 293 foot
- Cemented in place
- Recording local seismicity, VSPs, small volume water injection

MICROSEISMIC MONITORING



September 13, 2011 Birmingham earthquake



Vibroseis trucks

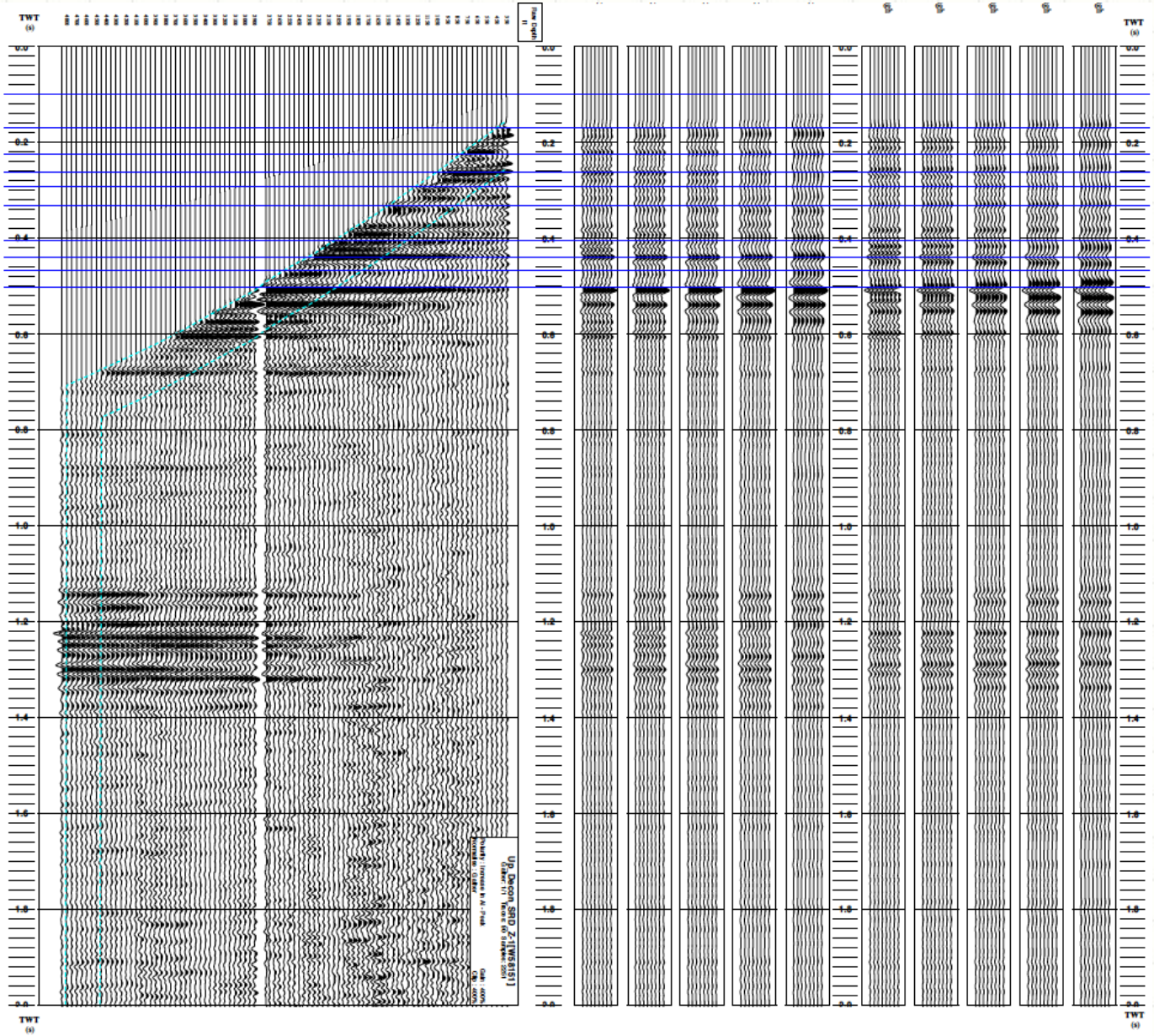
VERTICAL SEISMIC PROFILES

One zero offset and three ~2500 foot offset VSPs

VibroSeis source – 6-96 Hz 12 second sweep

3-component geophones in main well with 50 foot spacing

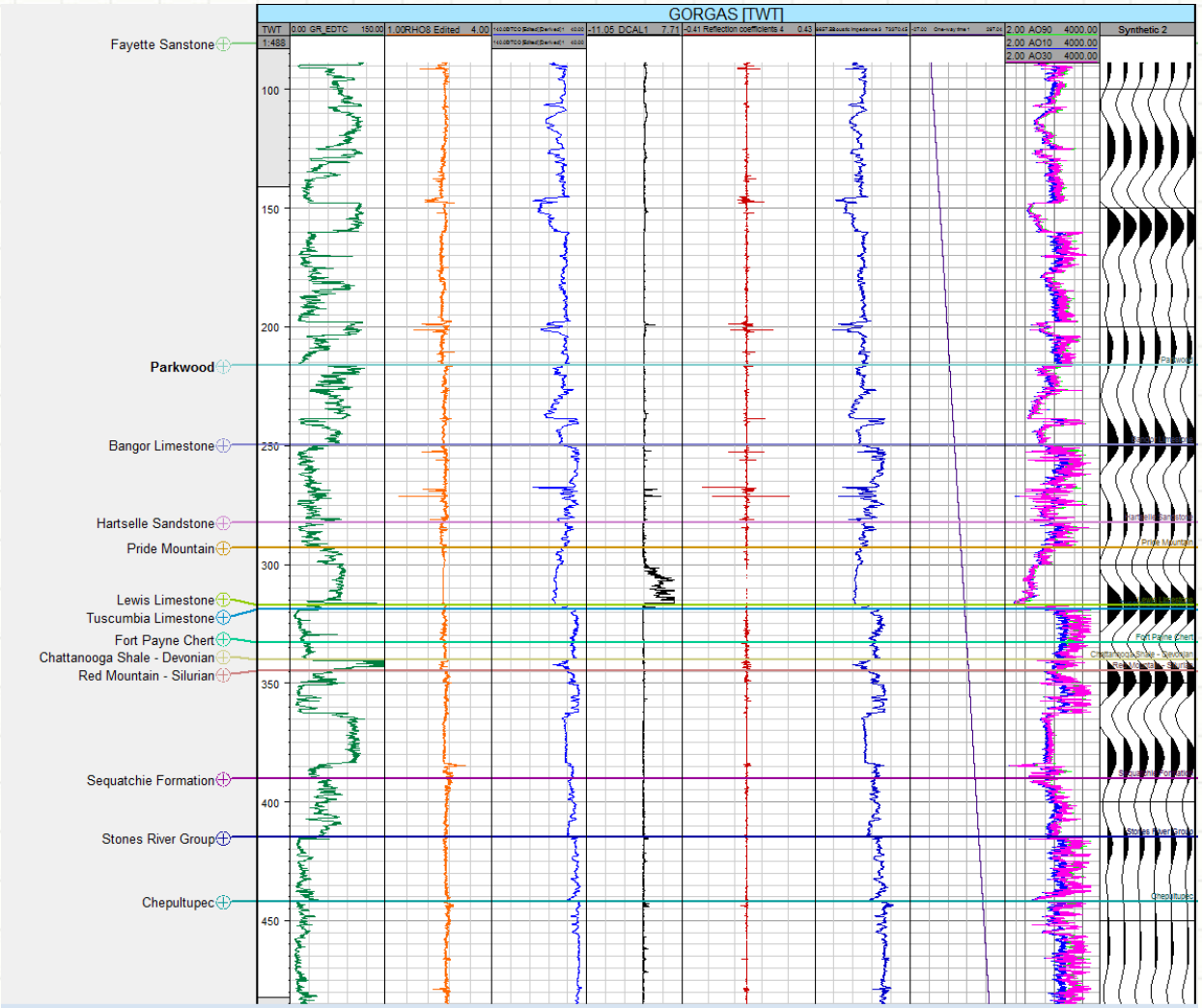
VERTICAL SEISMIC PROFILES

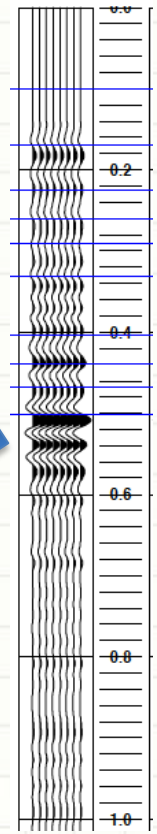


Zero-offset VSP clearly images key horizons

Offset VSPs are still being processed

WELL-SEISMIC INTEGRATION





Zero-offset VSP

Gamma Density Sonic Caliper RC Acoustic Impedance T-D Resistivity Synthetic

CONCLUDING REMARKS

- Regional characterization approaching completion
- Gorgas #1 well drilled, cored, logged, and tested
- Geological and geophysical data being analyzed and prepared for incorporation into reservoir and seal models
- Laboratory work, including mineralization experiments, is ongoing