(ARRA Site Characterization) – Geologic Characterization of the Triassic Newark Basin of Southeastern New York and Northern New Jersey

(DE-FE0002352)

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Sandia Technologies, LLC

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and Building the Infrastructure for CO_2 Storage
August 21-23, 2012

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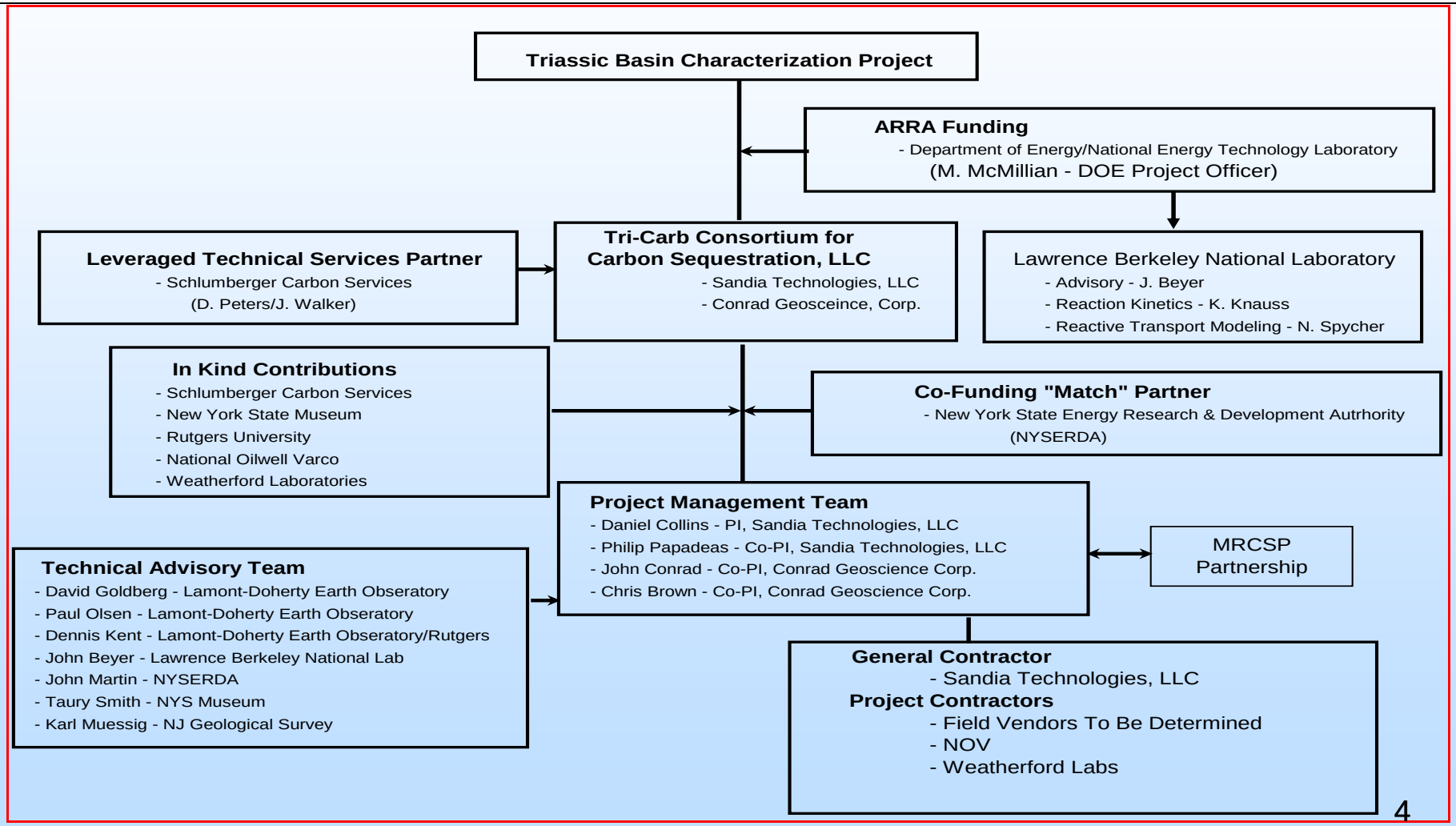
- **Project Team Members:**

  Dan Collins, PI/PM, Sandia Technologies, LLC; Conrad Geoscience/PVE-Scheffler, New York State Museum, Lamont Doherty Earth Observatory, Rutgers University, Earthview Associates, Schlumberger, Lawrence Berkeley National Laboratory

Presentation Outline

- Project Benefits to the Program
- Project Overview- Objectives, Goals
- Project Accomplishments
- Preliminary Results
  - Integrated Seismic-Geologic-Reservoir Data
- Summary
  - Key Findings, Lessons Learned
- Future Plans
  - Lamont Doherty Test Well
  - Lawrence Berkeley Nat. Lab - CO_2 Reaction Modeling

Project Team Organization Chart



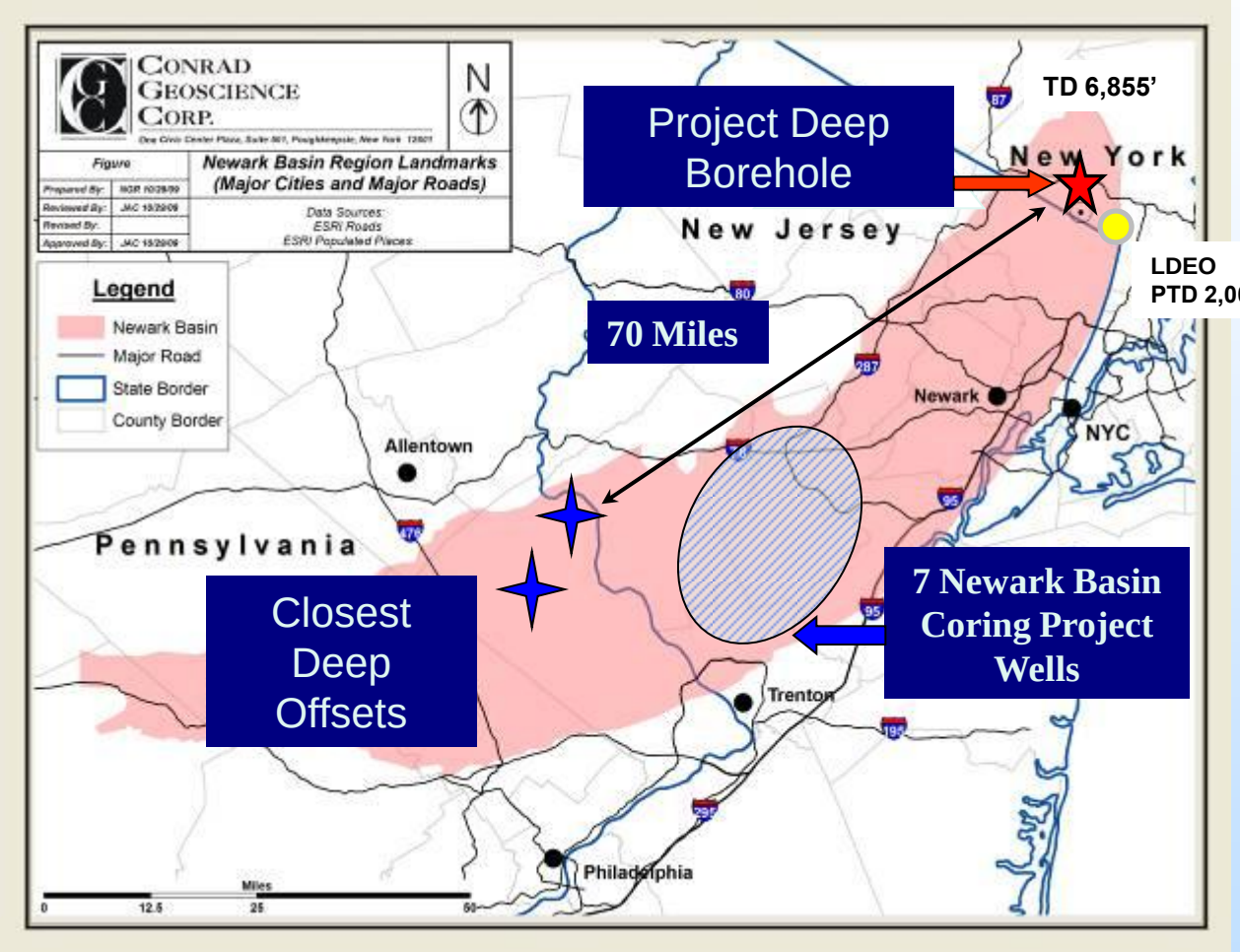
Benefits to the Program

- Project Goals:
  - Advance Geologic Knowledge of Newark Basin for potential Carbon Storage in northeast corridor
  - Provide baseline Geologic Characterization of all Formations in Northern Newark Basin
  - Perform Assessment of subsurface geologic structure via integrated seismic data, and reservoir potential of formations encountered
- Project Benefits:
  - Seismic data, Test well drilling, reservoir analysis of geologic formations has expanded basin concepts
  - Refine volumetric storage estimate values in basin

Project Overview:
Objectives/Program Goal

- **Primary Objective** is to evaluate sequestration potential within the poorly and sparsely explored Triassic-aged Newark Basin.
  - Identify presence/absence of commercial scale reservoirs at the northern end of the basin.
  - Identify presence of appropriate confining zone(s)/Cap Rocks.
  - Evaluate geomechanics of the sedimentary column for injection scenarios.
  - Characterize hydro-geologic regime of flow layers
  - Correlate test wells to offset basin wells formations
  - Perform laboratory modeling of CO_2 flow-reaction

Physiogeographic Setting of the Newark Basin



- Newark Basin stretches from Rockland County, New York, southwest across northern New Jersey, and into southeastern Pennsylvania (140 miles long by 32 miles wide)
- Geographic extent ~ 2,700 square miles
- The Newark Basin is in close proximity to large population areas and a heavily industrialized section of the country (28 MM tons/year CO_2 in closest NY/NJ counties)
- Deep offsets (mid 1980s) are more than 70 miles away – oil and gas exploration
- 1990s 7 Newark Basin Coring Project wells Central New Jersey ~3,500 ft deep – chronostratigraphy focus

Project Overview: Objectives (Continued)

- **Secondary Objectives** Include:
  - Gain permitting experience (seismic and well drilling) in New York.
  - Create meaningful near-term and long-term employment, forming the basis for building and initiating foundations for CCS industry using the Newark Basin geologic formations
  - Publish technical findings, perform data sharing,
  - Integrate data with MRCSP & NATCARB

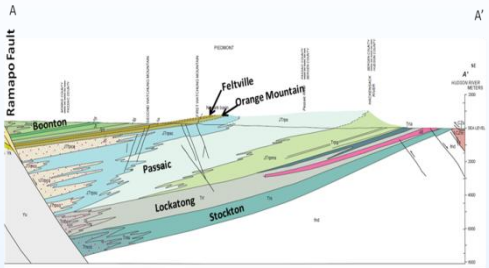
Project Accomplishments

- Completed initial characterization and model of the Northern Newark Basin – March 2011
- Completed acquisition and processing of 2-D seismic lines – March/April 2011
- Completed permitting, drilling, coring, logging and testing of deep stratigraphic test boring to 6,885 ft – August/October 2011
- Successful public outreach ahead of well drilling and “Open House” during site activities – September 2011
- Completed baseline rotary core plug analyses, reservoir evaluation – July 2012
- Developed Integrated Seismic-Geologic Structural Model – July 2012

Preliminary Results

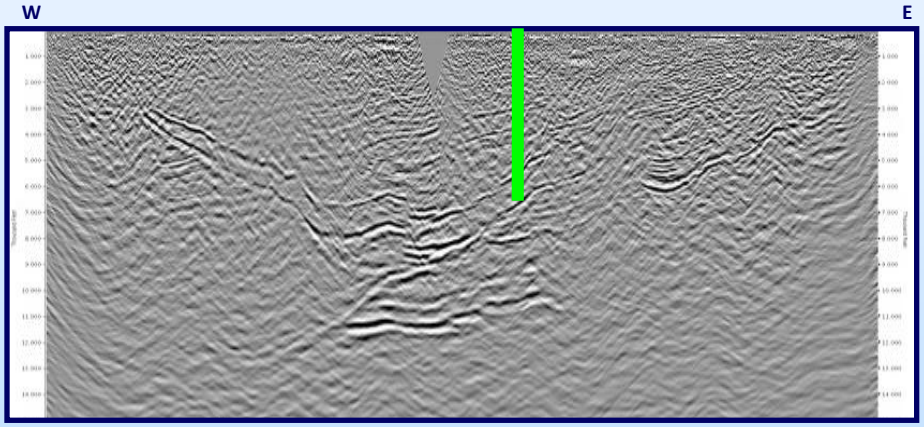
- At this Well location, best sandstone development is in the shallower portions of the well (Unit 1 ~2,100 to 2,500 ft, Unit 2 – 2,800 – 3,200 ft, Unit 3 ~ 3,650 – 4,250 ft)
- Formation Pressures indicate a freshwater gradient, placing supercritical CO_2 window below a depth of 2,500 feet
- Pump-through water resistivities at 2,322 feet and 3,058 feet indicate brackish waters only (~3,000 ppm NaCl). "Quicklook" log calculations to total depth indicates mainly <10,000 ppm NaCl (i.e. would be classified as USDW, underground sources of drinking water). Need to look deeper in the basin (New Jersey/Pennsylvania area for saline horizons).
- Confirmed presence of abundant lithified mudstones that can act as confining caprock layers. MDT wireline Mini-frac testing of two intervals up to tool limits of +/-5,500 psi (3,055 feet and 3,510 feet), show greater than 1.5 psi/ft minimum breakdown (frac) pressure.
- Potential trapping mechanisms are present in homoclinal dip of sediments being cross-cut by the Palisades Sill

Subsurface Interpretation Steps



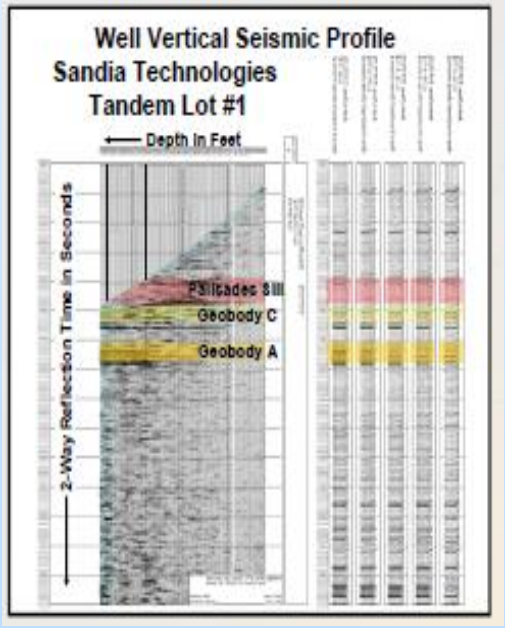
Historical Conceptual
Geologic View

2-D Seismic Processed

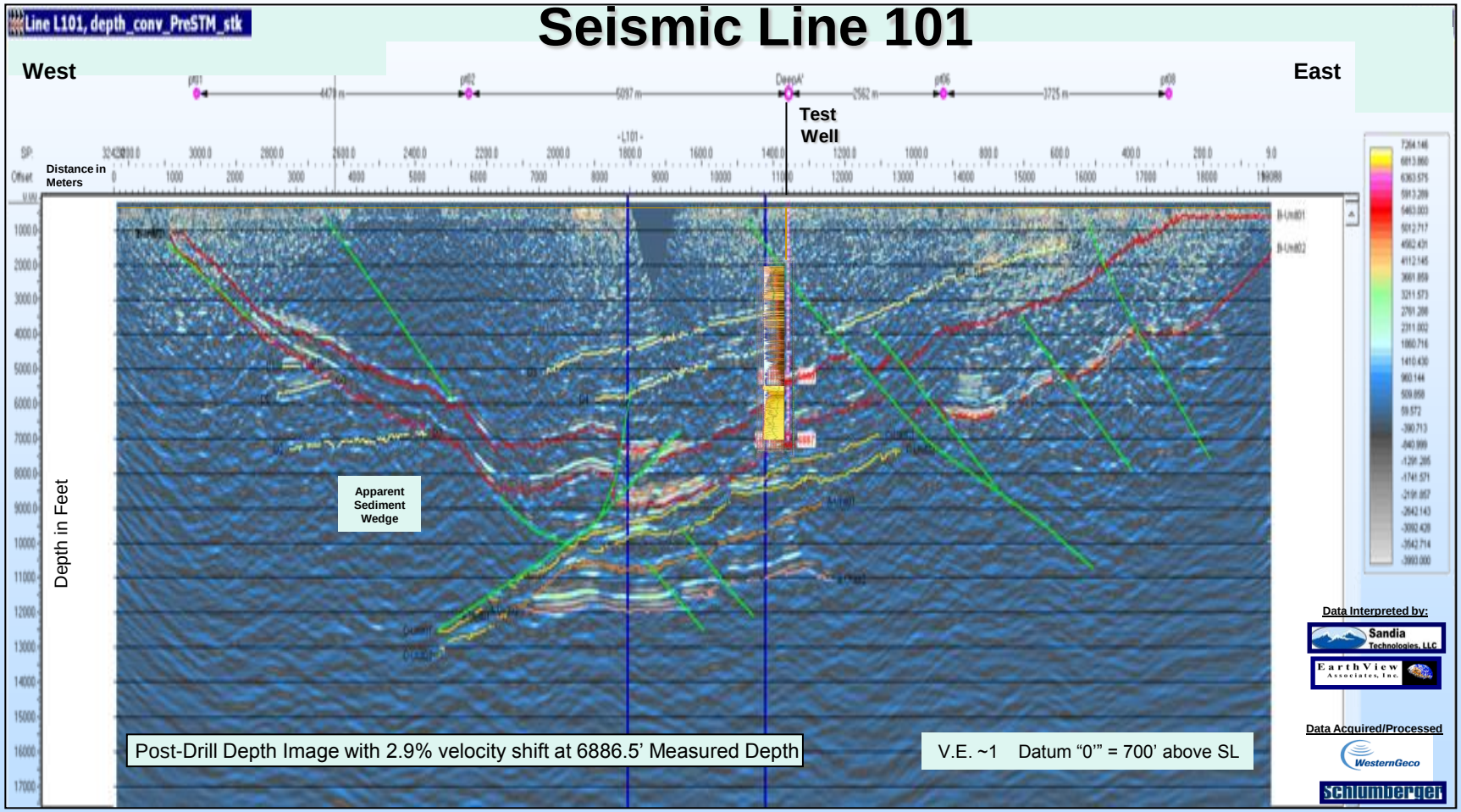


Pre-Stack migration of the cross-dip 2-D seismic line and location of the TriCarb Tandem Lot 1
Well completed at TD = 6,885 ft (2,295 m)

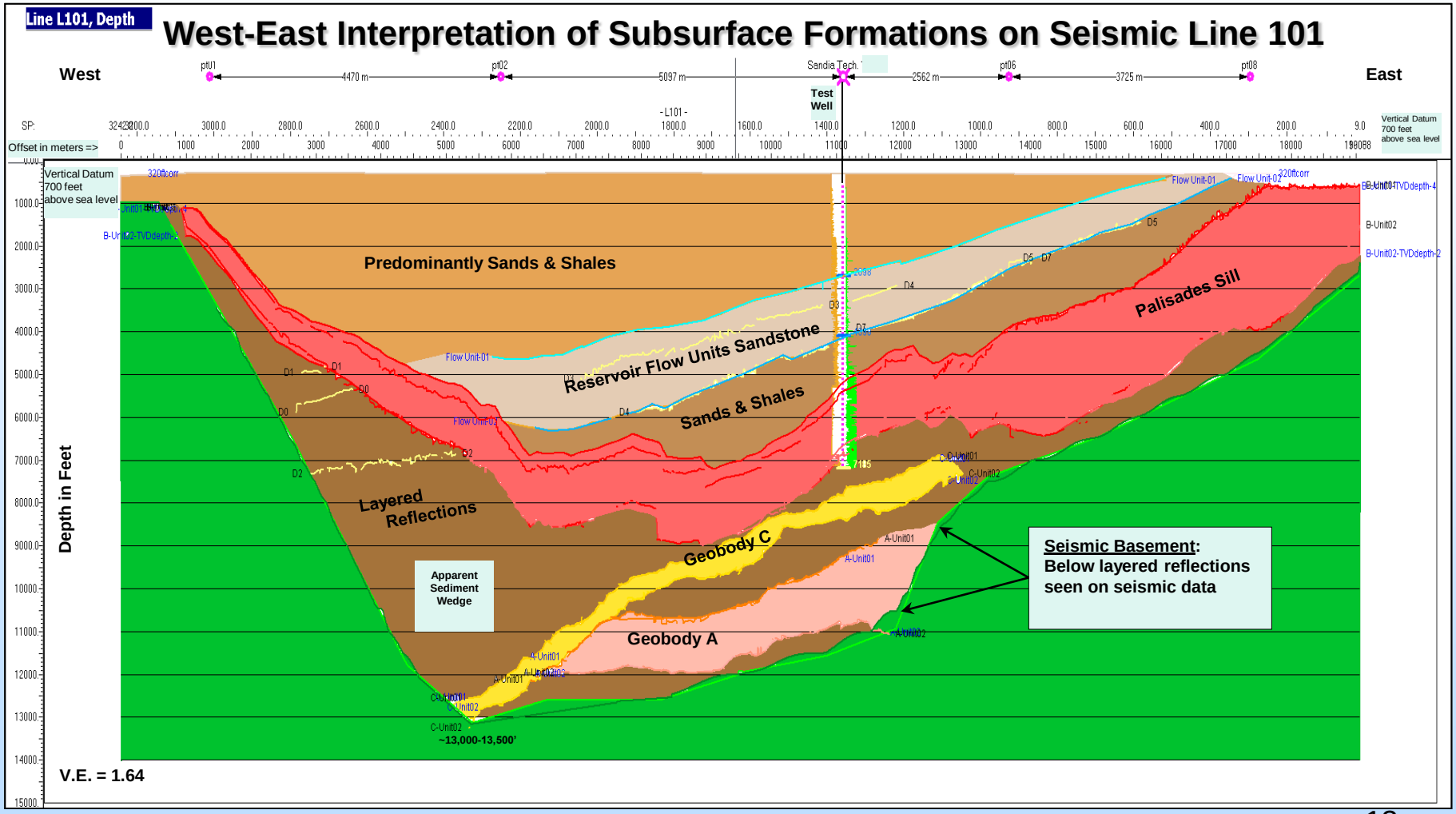
Borehole VSP
Seismic Processed



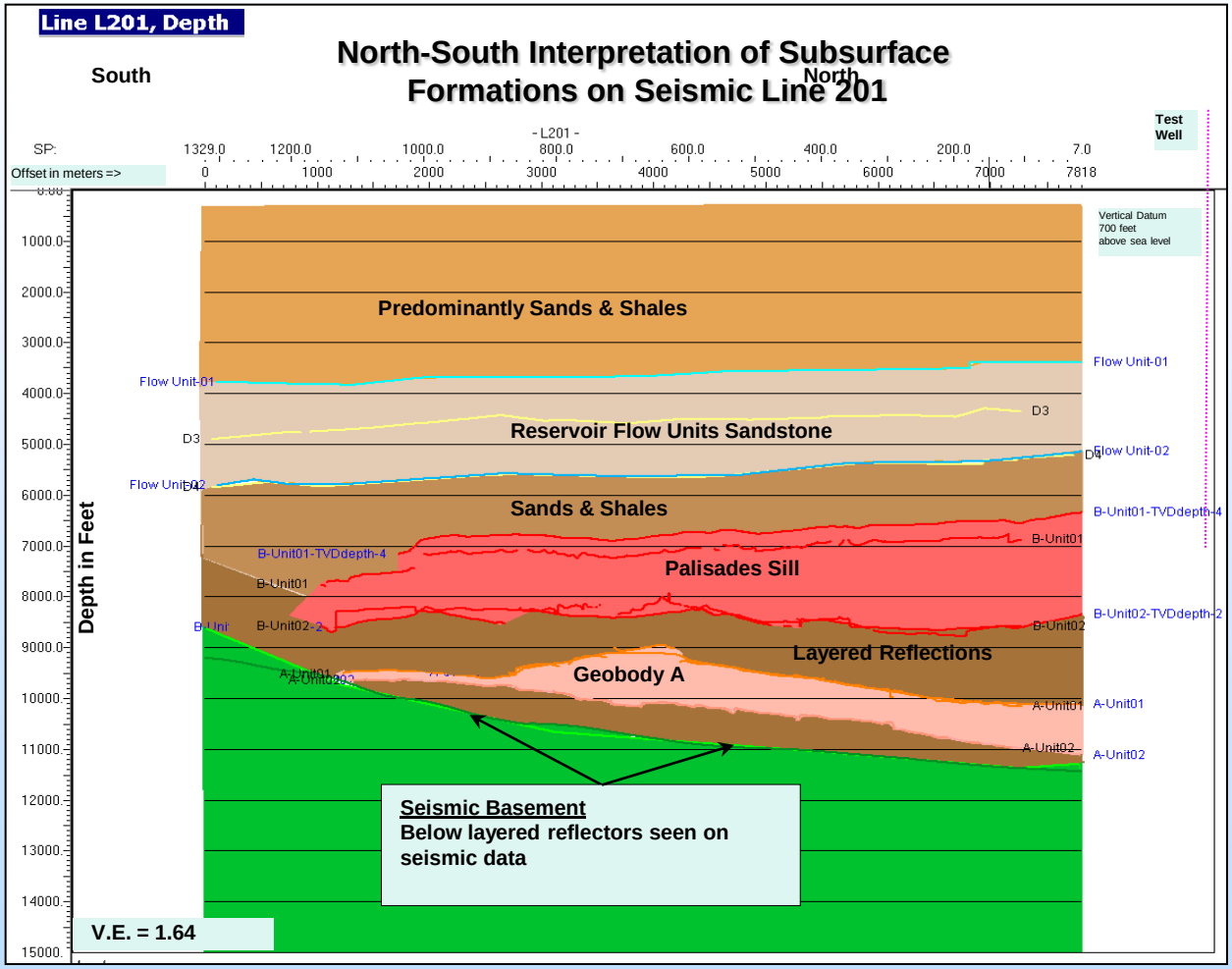
Initial Seismic Interpretation



Seismic Mapped Interpretation

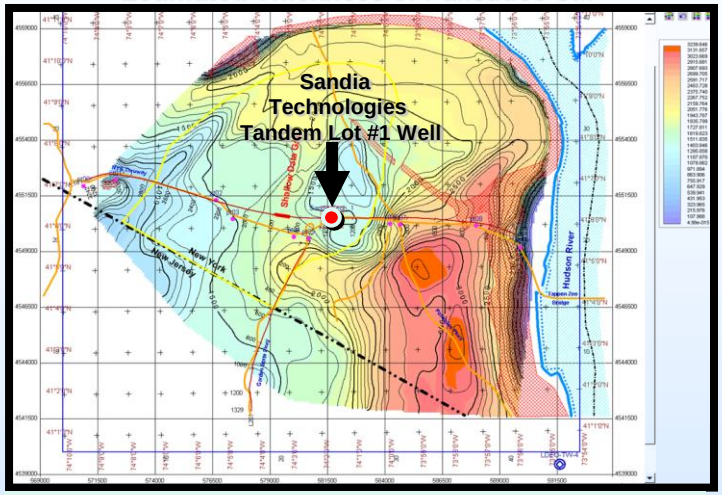


Seismic Mapped Interpretation

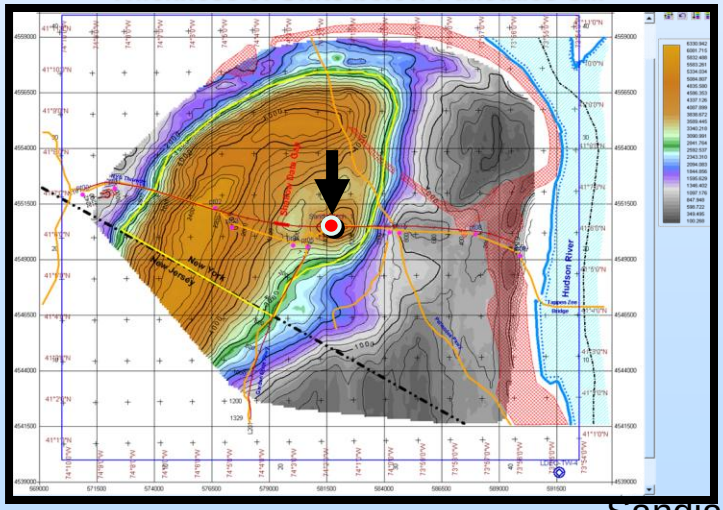


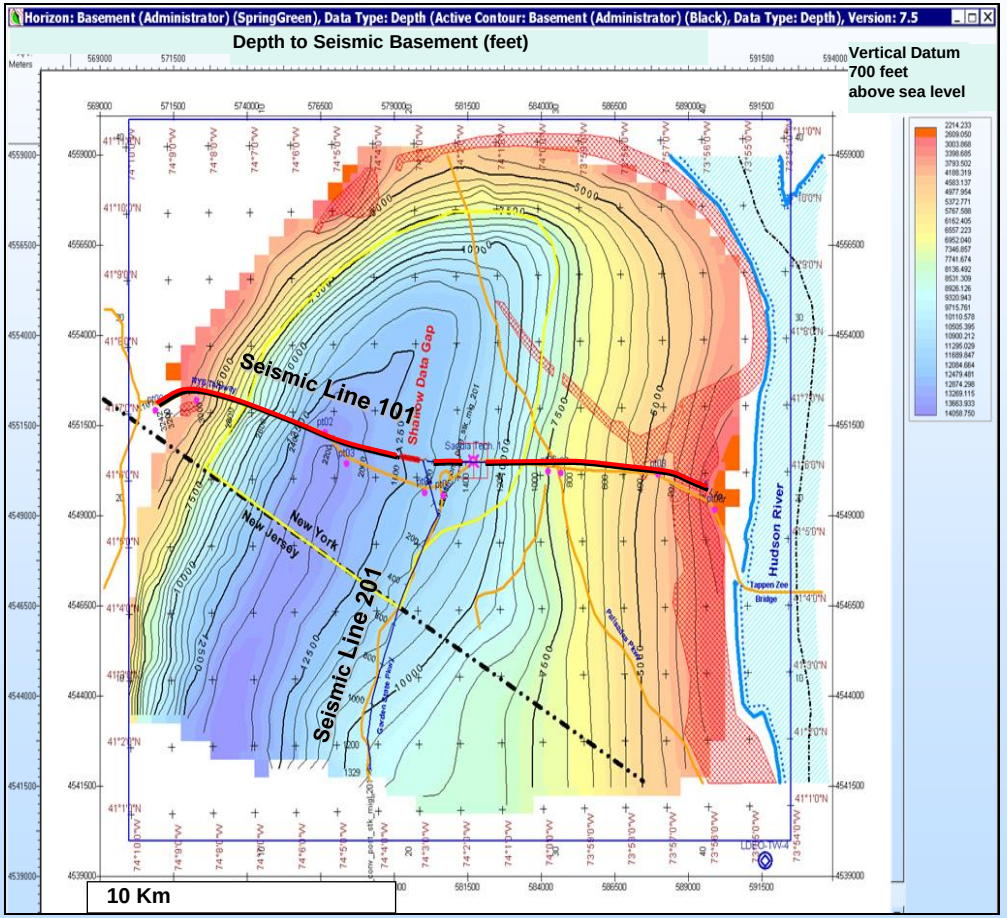
Seismic Mapping

Estimated Thickness of Palisades Sill

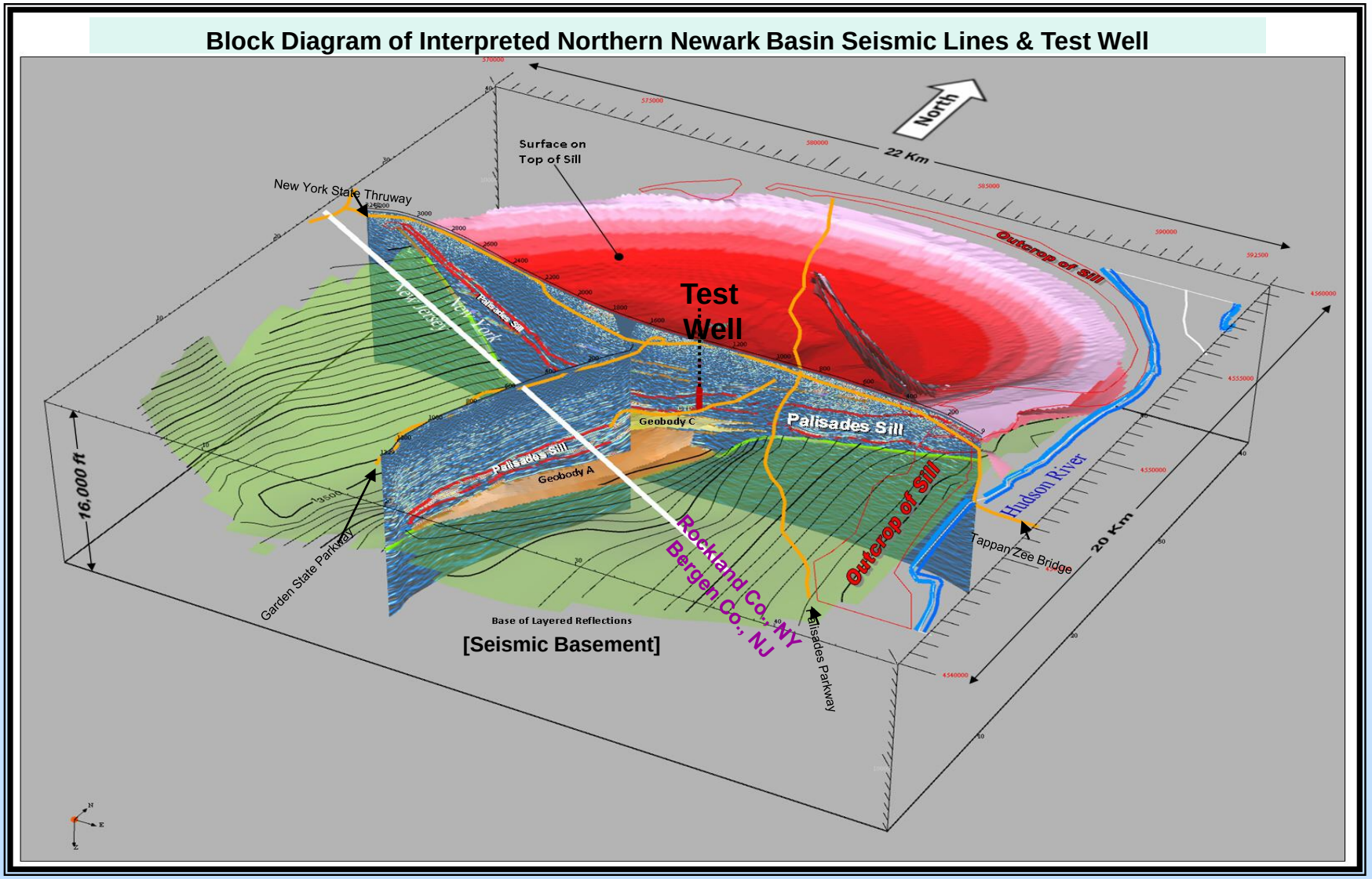


Thickness of Units below Palisades Sill





Integrated Block Model of Northern Newark Basin



Summary

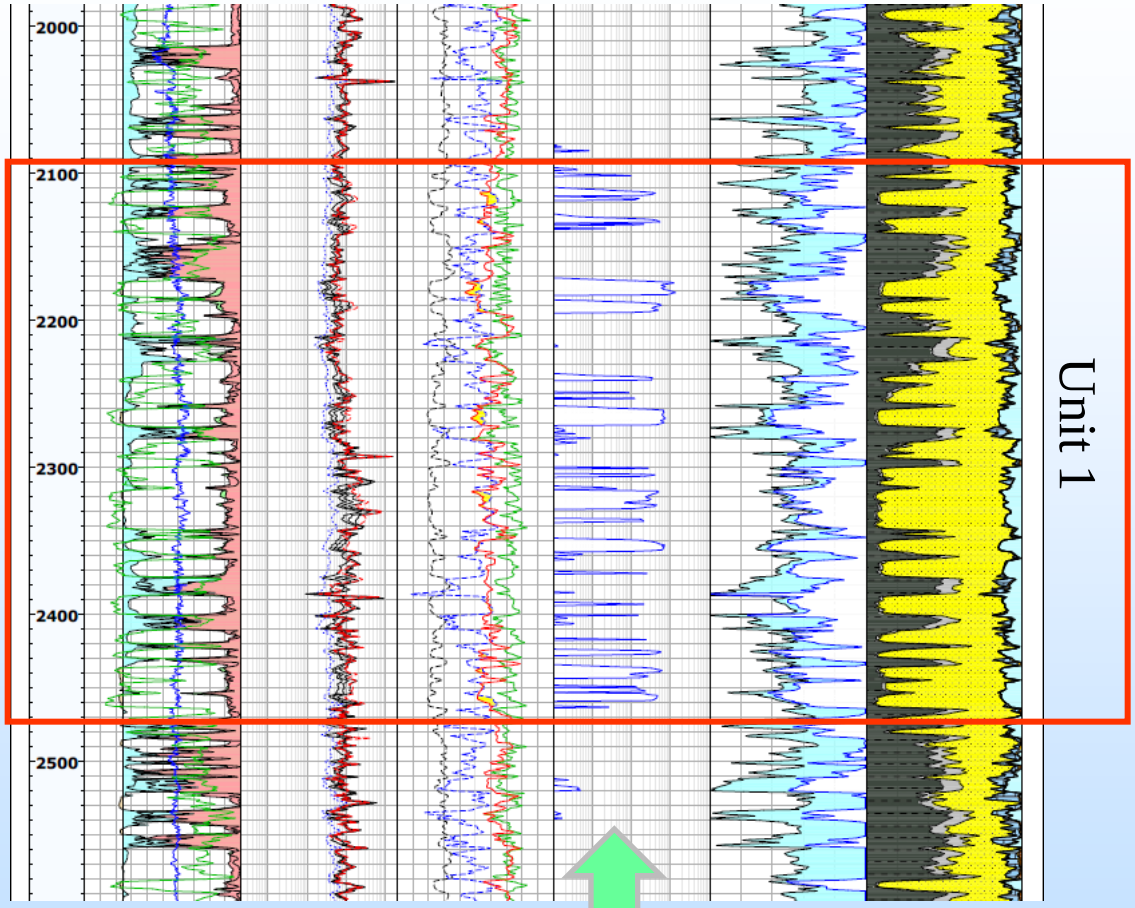
- Key Findings
- Lessons Learned
- Future Plans

Key Findings

- At the deep test well location sandstone development decreases with depth, however, 3 Reservoir Flow Units identified (Unit 1 ~2,100 to 2,500 ft, Unit 2 – 2,800 – 3,200 ft, Unit 3 ~ 3,650 – 4,250 ft) – poor sandstone development below 4,250 feet
- Formation Pressures indicate a freshwater gradient, placing supercritical CO_2 window below a depth of 2,500 feet
- MDT Formation water recovery at 3,058 feet and lab analyses indicate brackish waters only (<10,000 ppm NaCl)

  i.e. interval would be classified as underground source of drinking water.
- Well confirmed presence of abundant lithified, low permeability mudstones that can act as confining caprock layers. MDT Minifrac testing of intervals ran up to tool limits of +/-5,500 psi (3,055 feet and 3,510 feet), show >1.5 psi/ft minimum fracture pressure.
- Basin stress regimes identified with borehole FMI, geomechanics, magnetic data
- Potential added trapping mechanisms are in homoclinal dip of sediments being cross-cut by the Palisades Sill and below the sill
- Faulting adds more potential localized reservoir traps

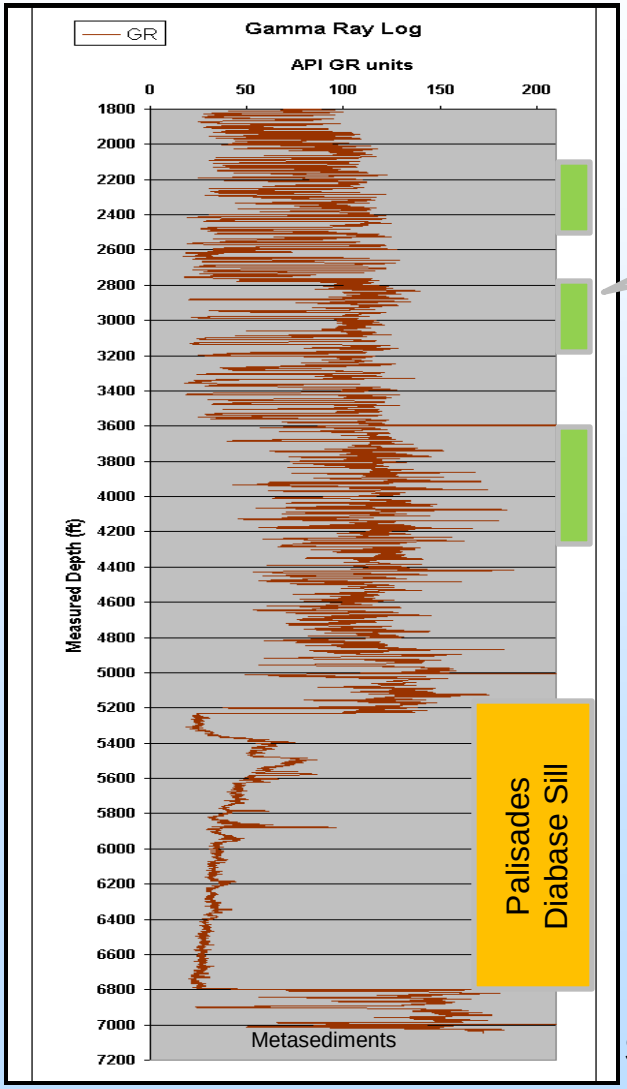
Open Hole Logging Snapshot – Reservoir Unit Example



Permeable Sandstones

- Logs indicate three potential flow units (Unit 1 ~2,100 to 2,500 ft, Unit 2 – 2,800 – 3,200 ft, Unit 3 ~ 3,650 – 4,250 ft)
- Note: first unit would need to be followed deeper into the basin sediment wedge to be at “supercritical” CO_2 conditions
- Low Salinity, TDS [near fresh water recharge area]

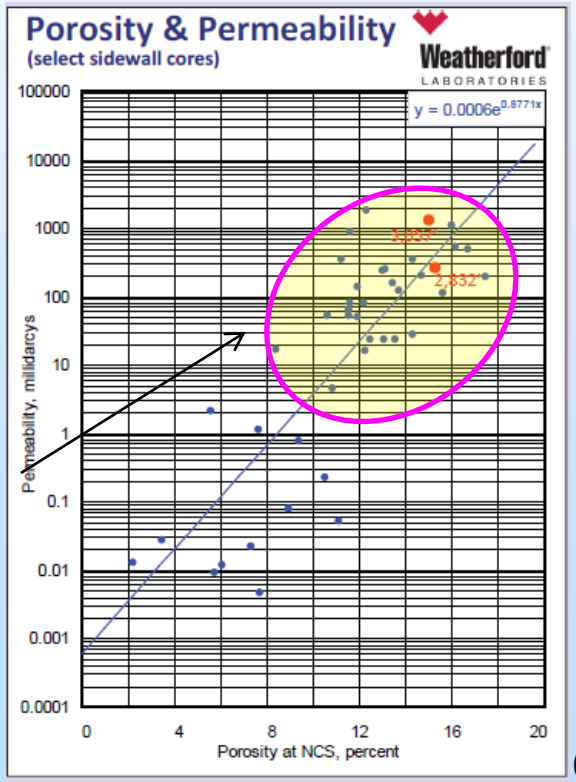
Type Log of Reservoir Units



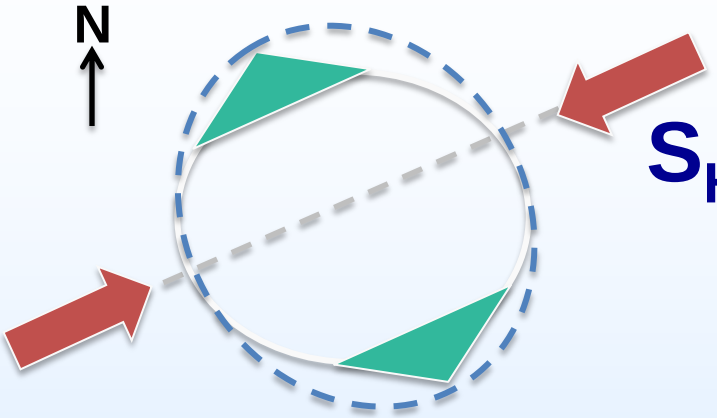
Reservoir Flow Units

Reservoir Quality With Porosity/permeability

Suggest Minimum Cutoff For Commercial Site
> 10 % porosity
> 10 md permeability



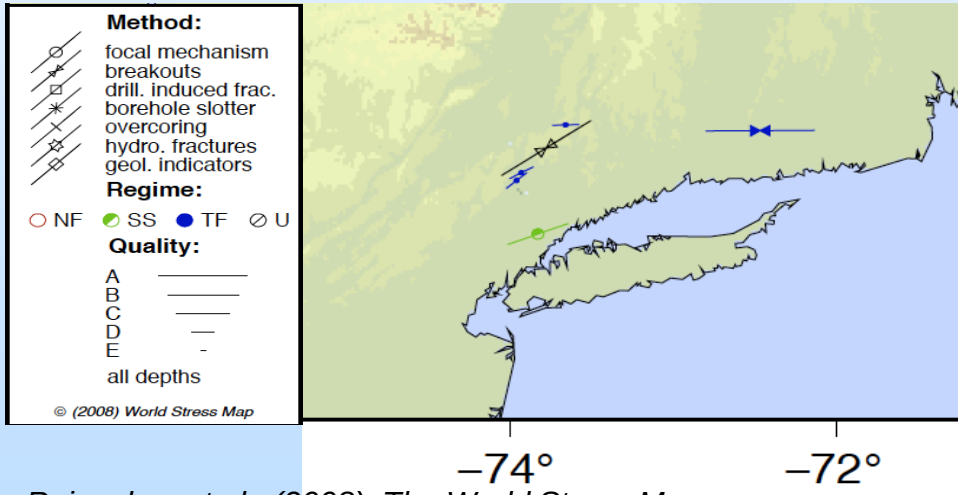
Regional Stress Orientation



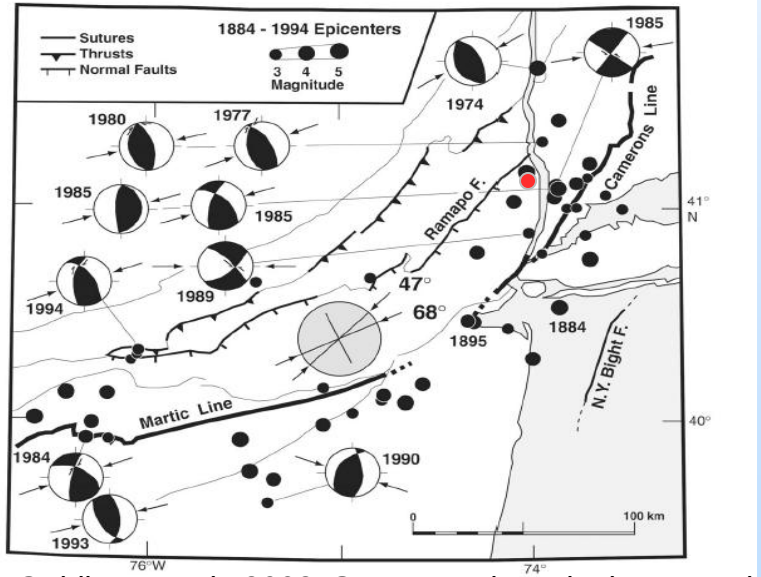
Lamont Doherty Earth Observatory

Early Findings:

- All stress data suggest maximum horizontal stress oriented NE-SW
- Basin Seismicity potential
- Data is consistent with other regional evidence for reverse/strike-slip regime

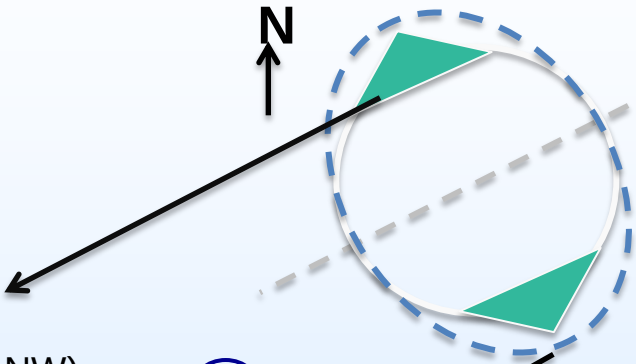


Reinecker, et al., (2008), The World Stress Map (www.world-stress-map.org)

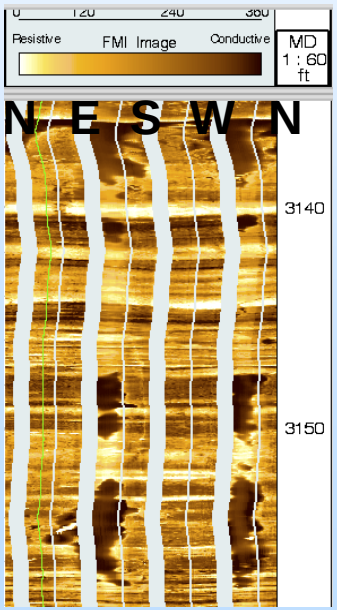


Goldberg et al., 2003, Stress Regimes in the Newark basin: evidence from core and downhole data

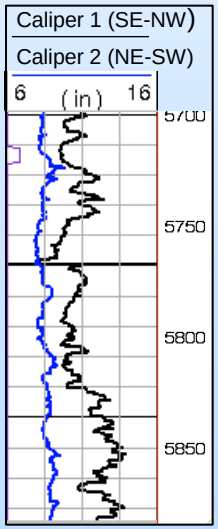
Borehole Stress Indicators



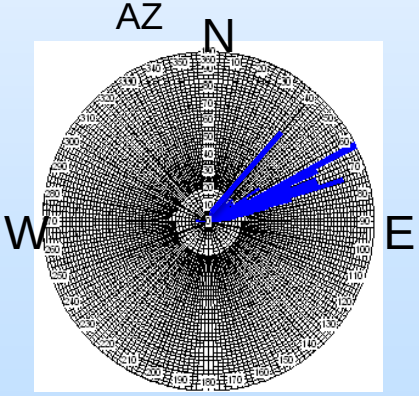
1. Breakouts in sediments (SE-NW)



2. Wellbore deformation in the sill (SE-NW)

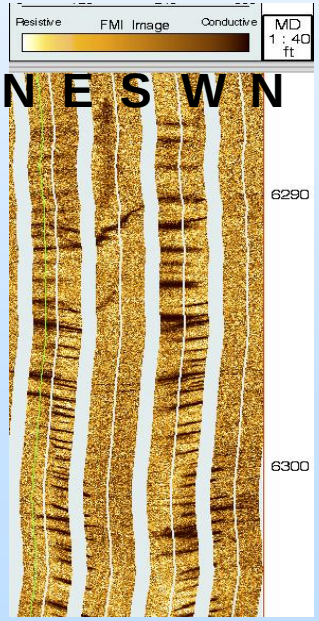


3. Fast shear AZ



(from sonic anisotropy analysis by Schlumberger)

4. Drilling-induced and drilling-enhanced fractures (NE-SW)



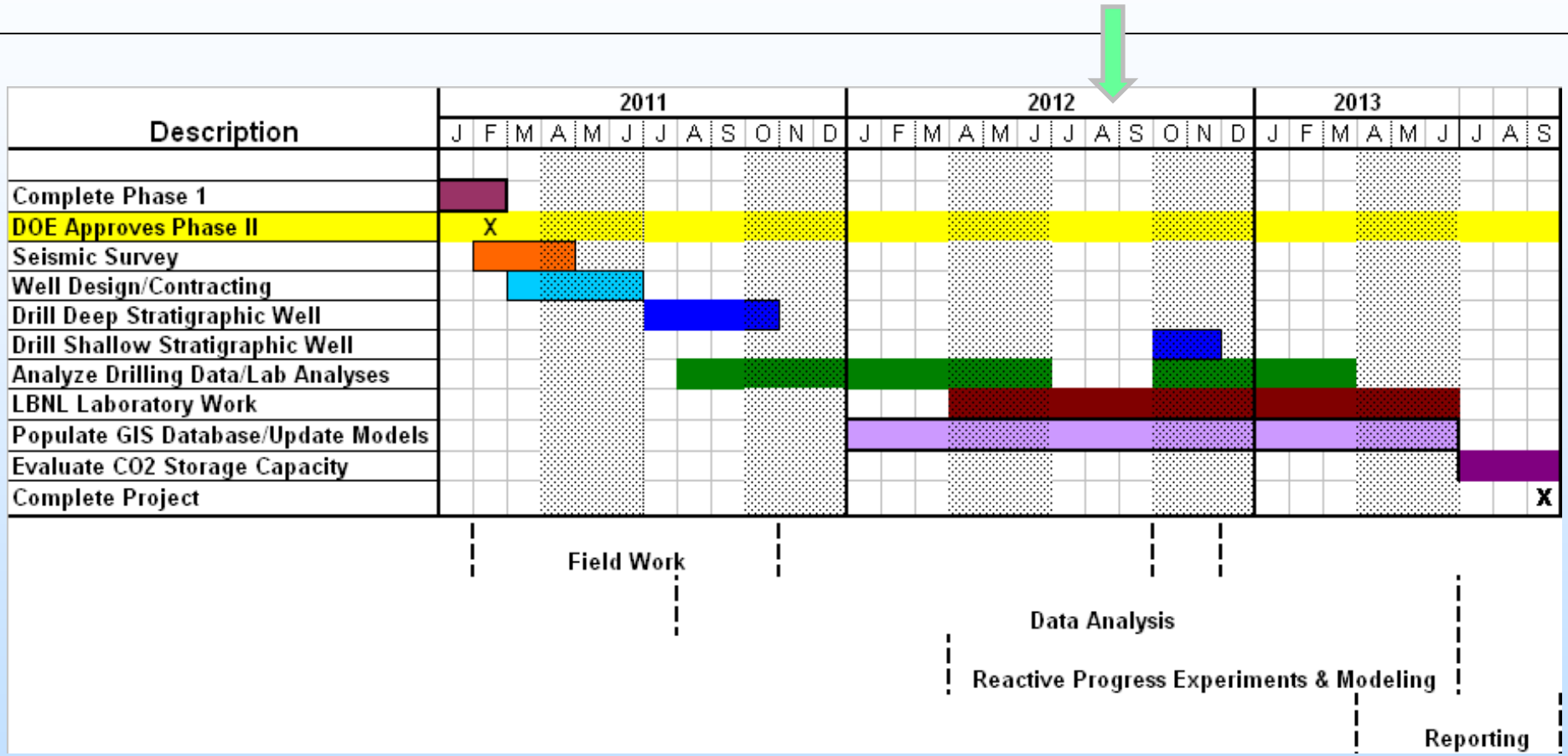
Lessons Learned

- County regulatory concerns/requirements may not agree with state Permit requirements – may result in increased well construction costs, i.e. local request for additional surface casing
- Research Field Work can be accomplished in an urban-suburban “developed” setting, however, costs will be higher than budgeted, i.e. seismic on NYS Thruway, permitting charges, access
- Early outreach to local Rockland Co., NY officials helped facilitate education outreach to key stakeholders and wider public
- Northern end of the basin is significantly more complex than originally anticipated, with faulting, igneous dikes, metasediments
- Palisades Sill thickness was approximately 1100 feet, with halo zones of meta-sediments, altered intervals above-below diabase.
- Defined Reservoir Flow zones are indicated from logs, cores, MDT fluids, integrated ELAN
- Integrated Seismic-Geologic structure, thickness information show effect of the sill on sediments, faulting, thinning
- Apparent deeper wedge of sediments may exist to 13,500 feet
- Middle deeper Newark Basin (NJ) may contain better (saline) reservoirs away from thermal influence of Palisades Sill

Future Plans - Next Steps

- Complete whole core evaluation by New York State Museum – 4thQ 2012
- Complete whole core plug commercial Laboratory Analyses – Weatherford Laboratories 4thQ 2012
- Complete integration of core data and geophysical well logs – Schlumberger Carbon Services 4thQ 2012
- Permit and drill Shallow Well (2,000 ft continuous mineral core well) at Lamont Doherty Earth Observatory Campus – 4thQ 2012.
- Lawrence Berkeley National Laboratory performing reaction experiments and geochemical numerical modeling – complete by summer 2013.
- Project report and NATCARB data integration complete by September 30, 2013.

Gantt Chart


Description
2011
2012
2013
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
Complete Phase 1
DOE Approves Phase II
X
Seismic Survey
Well Design/Contracting
Drill Deep Stratigraphic Well
Drill Shallow Stratigraphic Well
Analyze Drilling Data/Lab Analyses
LBNL Laboratory Work
Populate GIS Database/Update Models
Evaluate CO2 Storage Capacity
Complete Project
X
Field Work
Data Analysis
Reactive Progress Experiments & Modeling
Reporting

Posters

- Newark Basin Project Team – 3 Posters
  - **Initial Integration of New Reflection Seismic Surveys with Observations from the Sandia Technologies Tandem Lot #1 and Palisades Sill Outcrop Distribution**
  - **Initial Analysis of Seismic Elastic Parameter Data from the Sandia Technologies, LLC Tandem Lot #1 Well**
  - **Characterization of the Northern Newark Basin: Preliminary Thin Section, Core and Log Analyses from the NYSTA Tandem Lot Well**

Questions?

Appendix

Bibliography

No peer reviewed publications have been generated from the project yet.

Following integration of data from 2nd well at LDEO expectations are to generate several publication areas.