Field Laboratory for Emerging Stacked Unconventional Plays (ESUP)

VIRGINIA TECH

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ESUP Project Update – 10/15/2020

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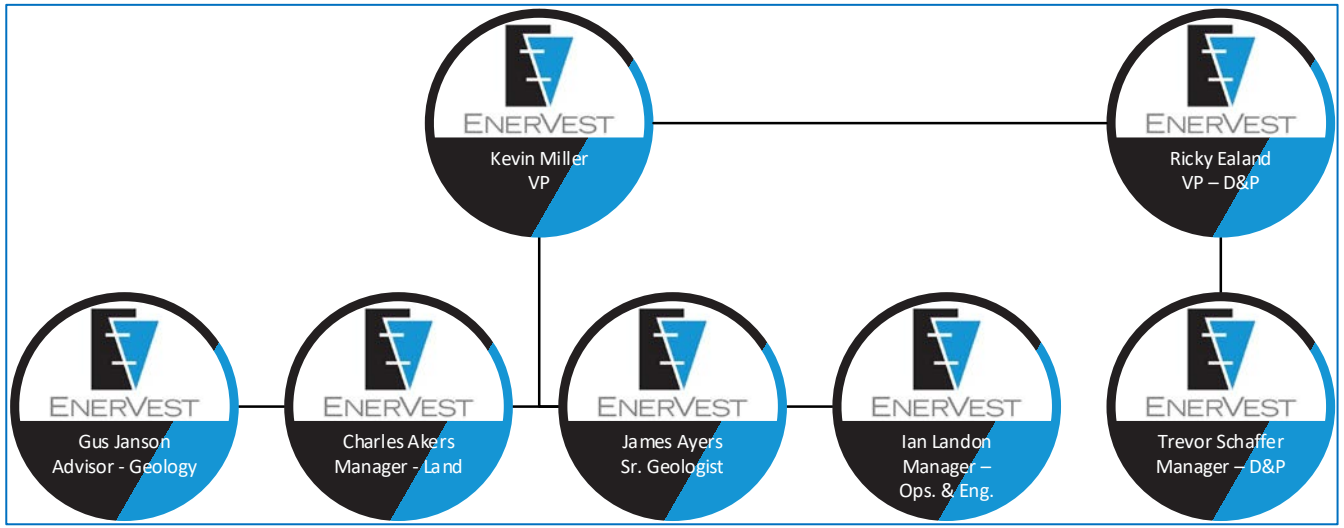
Acknowledgments

- Financial assistance for this work was provided by the U.S. Department of Energy through the National Energy Technology Laboratory's Program under Contract No. DE-FE0031576.
- Robert Vagnetti, U.S. DOE/NETL Project Officer

Outline

- Research Team
- Objectives
- Timeline
- Accomplishments
- Remaining Work

Project Team



*2 research associates and 5 graduate students supported

Advisory Stakeholder Group (ASG)

(Updated individually throughout negotiation Phase)

TECHNICAL EXPERTS

Randy Albert
Owner and CEO, Shale Advisory Group, Bluefield, West Virginia

Ed Diminick
Petroleum Engineer at Appalachian Energy, Inc

Jerry Grantham
Vice President-Southern Appalachian Division, Range Resources (retired), Abingdon, Washington County, Virginia

COMMUNITY LEADERS

Shannon Blevins
Associate Vice Chancellor for Economic Development and Engagement, The University of Virginia's College at Wise, Wise County, Virginia

Freddie Mullins
Freddie Mullins, Esq., Clintwood, Dickenson County, Virginia

John Schoolcraft
Board of Supervisors, County of Wise District III

ENVIRONMENTAL LEADERS

Leon Boyd
Virginia District Chair and Chair of the Southwest Virginia Coalfields Chapter, Rocky Mountain Elk Foundation, Buchanan County, Virginia

STATE GOVERNMENT

William Clear
Director of Finance and Project Administration, Virginia Department of Mines, Minerals and Energy, Big Stone Gap, Wise County, VA

Objectives

- Investigate and characterize the resource potential for multi-play production of emerging unconventional reservoirs in Central Appalachia.
  - **Drill and selectively core a vertical Basement Test well**, drilled to approximately 15,000 ft., through the Conasauga-Rome Petroleum System
  - **Well logging**, **core analysis**, **reservoir testing** and production information will be integrated with **reservoir simulations** to develop an assessment of the multi-play resource potential
  - An assessment will be made of the multi-play resource potential and a recommended strategy advanced for prudent development that considers regional **environmental** and **socioeconomic impacts**.

Historic Conasauga / Rome Tests and Producers vs. Recent Rogersville Shale Activity

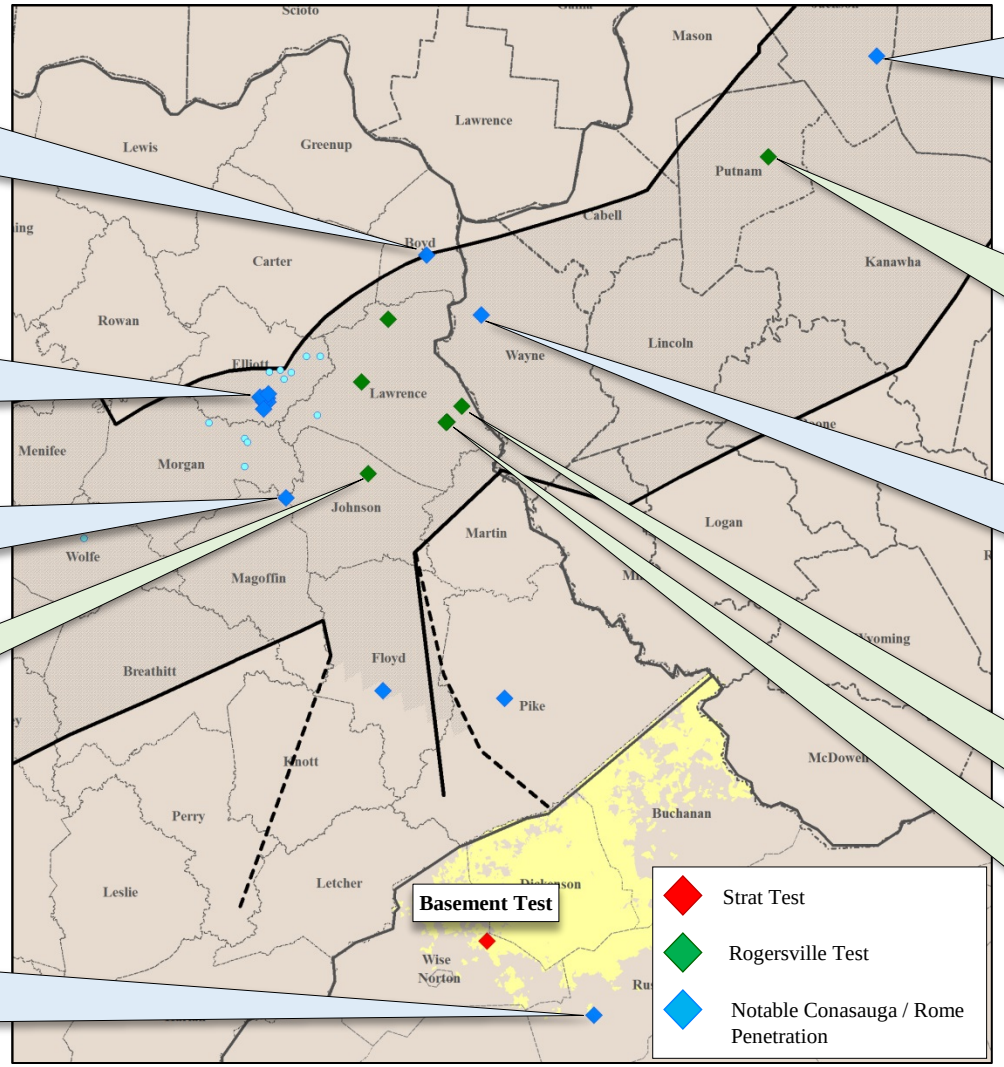
White #529
Inland Gas Co
Drilled 1967
Maryville Ls. Producer
- 90 MCFD / 32 BOPD
- 10,000 BO Produced
- Oil sourced from Rogersville Sh.

Homer Field
Discovered 1994
- Wells producer from sandstones within the Conasauga and Rome
- Structural Trap

Williams E #1
Ashland Exploration
Drilled 1985
- Nolichucky Sh. Producer
- Fractured Shale Reservoir
- 1.2 BCF / 42,000 BBL Condensate

EQT Prod Co #572360 H
Horizontal Tech Energy Co (EQT)
Horizontal Rogersville Test
TD Date: 6/7/2015
Fm @ TD: Rogersville Shale
Shut In

Price #1
Gulf Oil
Drilled 1977
- Indicates the presence of both Rogersville Shale and Pumpkin Valley Shale south of the proposed Characterization Well



McCoy #1
EXXON
Drilled 1975
Maryville Ls. Producer
- 6 – 9 MMCFD Natural
- .5 BCF Produced in 6 mo.
- Plugged: 9/9/1978
- Rogersville TOC: .29-.57

Amherst Industries #50
Cabot Oil & Gas
Vertical Rogersville Test
TD Date: 10/27/2014
- Maryville Ls. Producer
- 2.2 MMCFD (1st Month Avg.)
- CUM: 339,819 MCF

Smith JP #1
EXXON
Drilled 1974
- Excellent hydrocarbon shows
- Analysis indicates Rogersville is likely oil source for the White #529
- Rogersville TOC: 1.2-4.4

JH Northrup Estates #LAW 1
Chesapeake Appalachia
Vertical Strat Test
TD Date: 9/3/2015
- Excellent hydrocarbon shows in Maryville Ls., Rogersville Shale, Pumpkin Valley Shale & Rome Fm

Walbridge Holdings #1H
Bruin Exploration (Cimarex)
Horizontal Rogersville Test
TD Date: 2/23/2017
Fm @ TD: Rogersville Shale
Temporarily Abandoned

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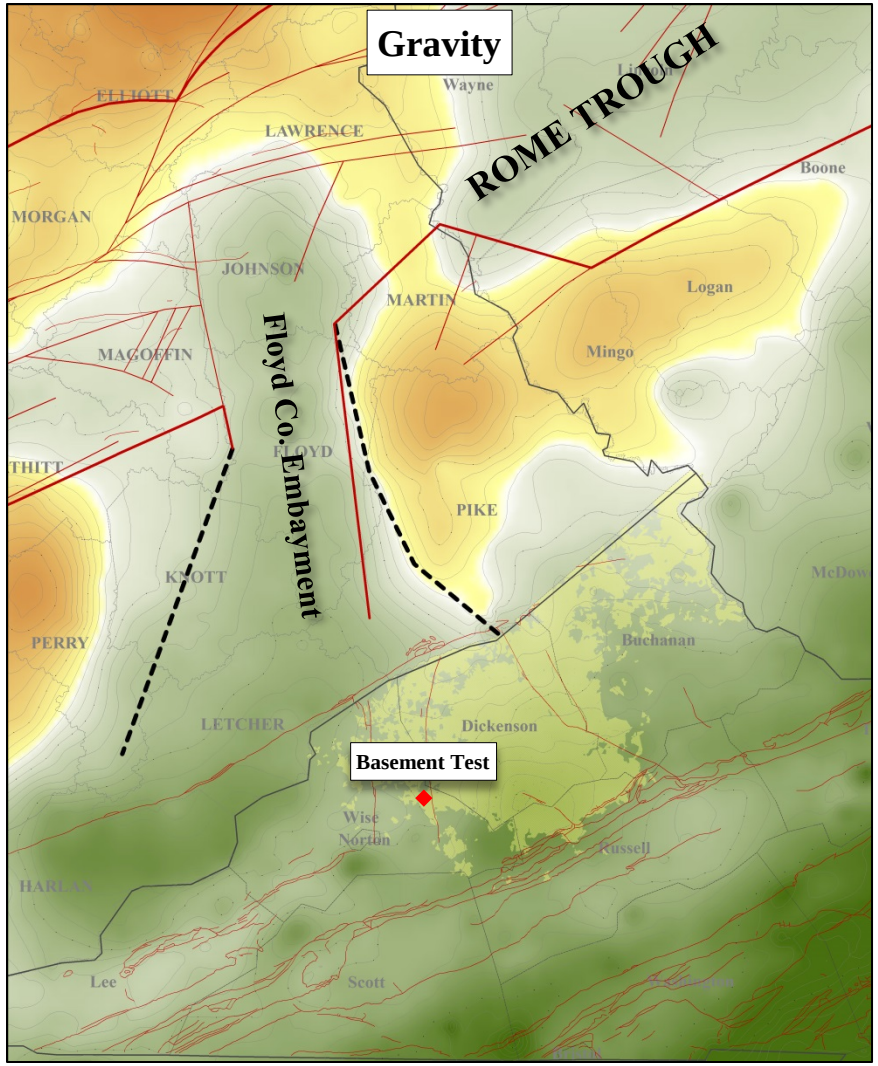
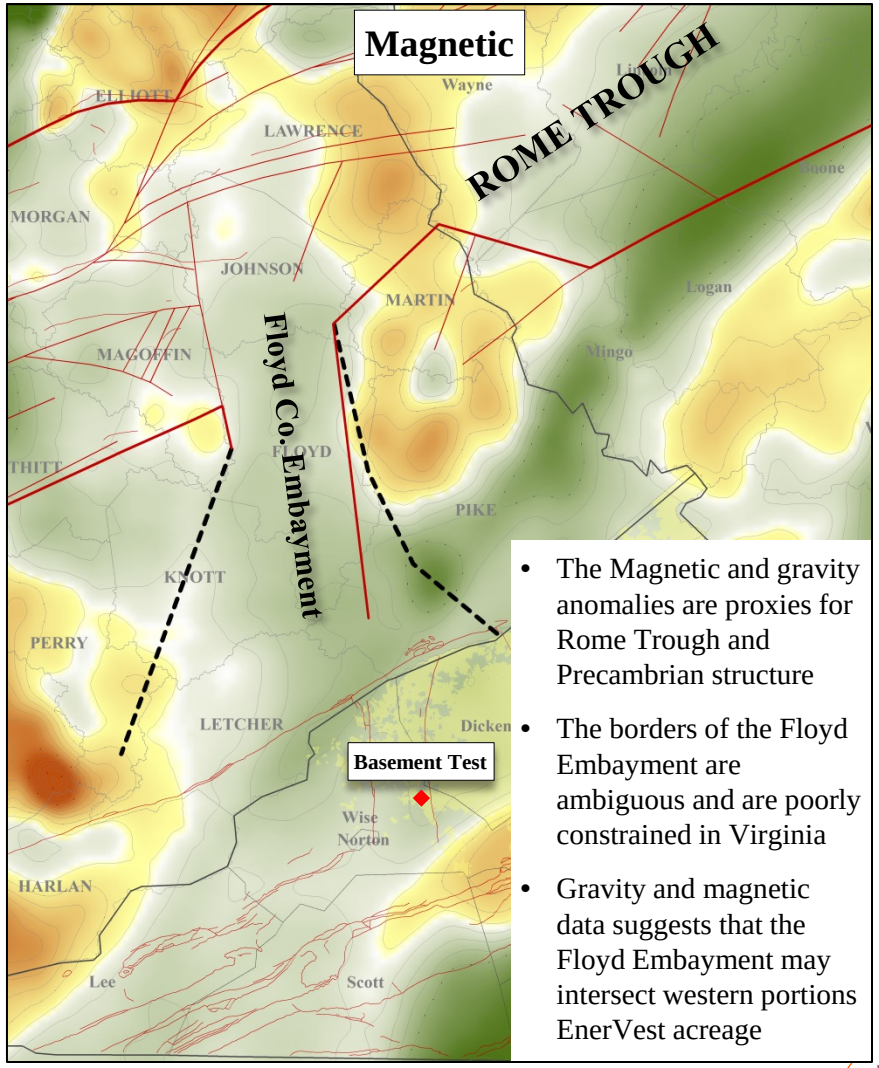
Floyd County Embayment Structure

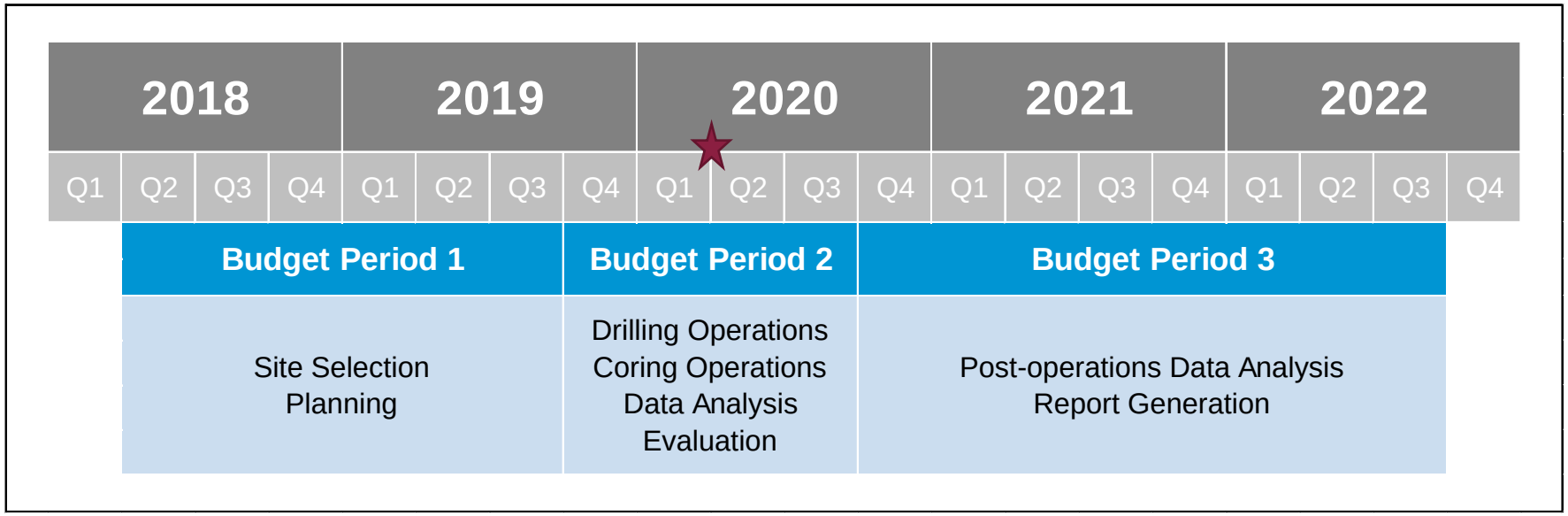
Gravity and Magnetic Data





- The Magnetic and gravity anomalies are proxies for Rome Trough and Precambrian structure
- The borders of the Floyd Embayment are ambiguous and are poorly constrained in Virginia
- Gravity and magnetic data suggests that the Floyd Embayment may intersect western portions EnerVest acreage

Project Timeline



★ 4/28/2020 – Spud deep well

11/20/2019: Pad construction completed

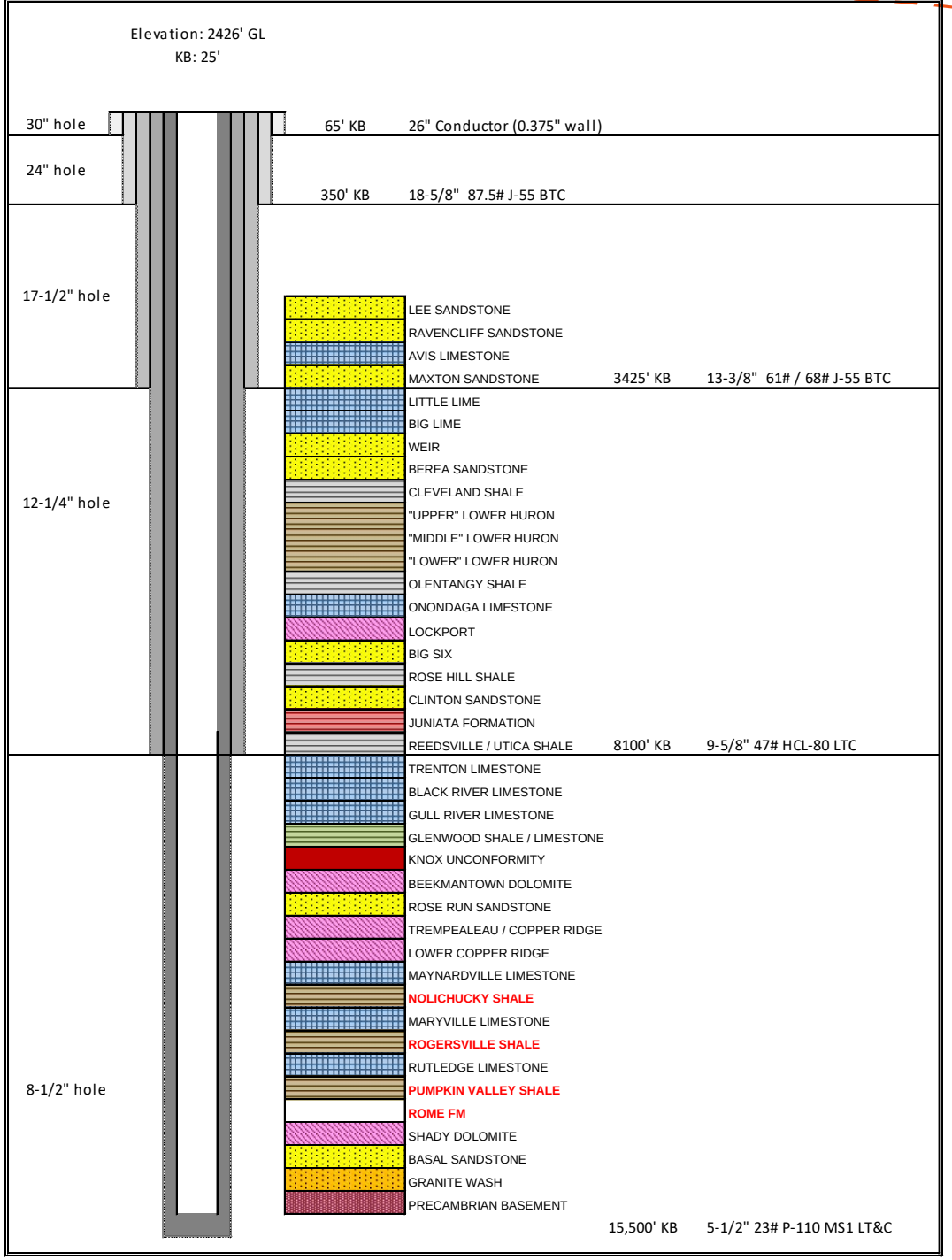
3/20/2020: Top hole completed

4/28/2020: Drilling Commenced

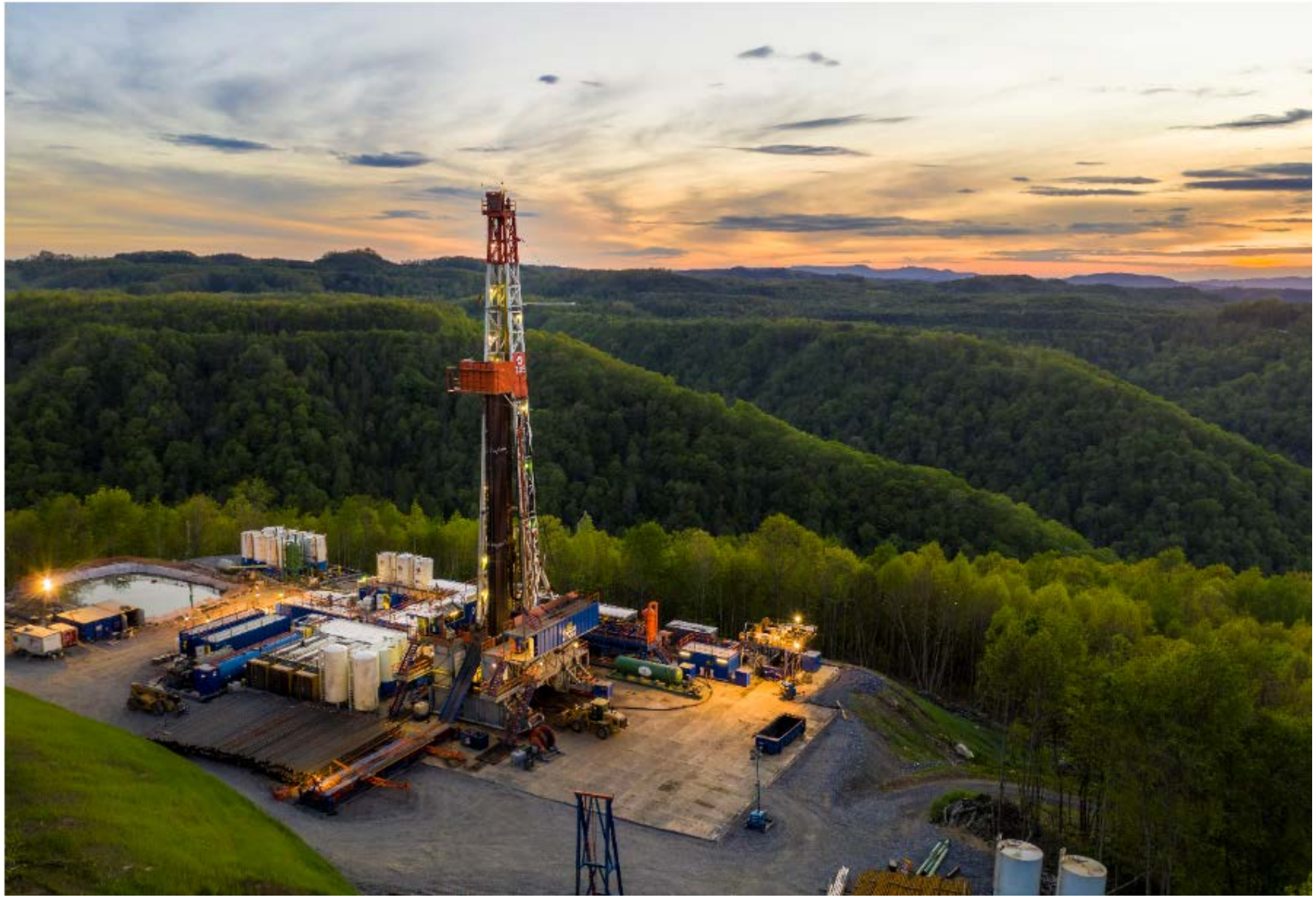
6/12/2020: Finished Logging and Coring

6/15/2020: Production Casing Set

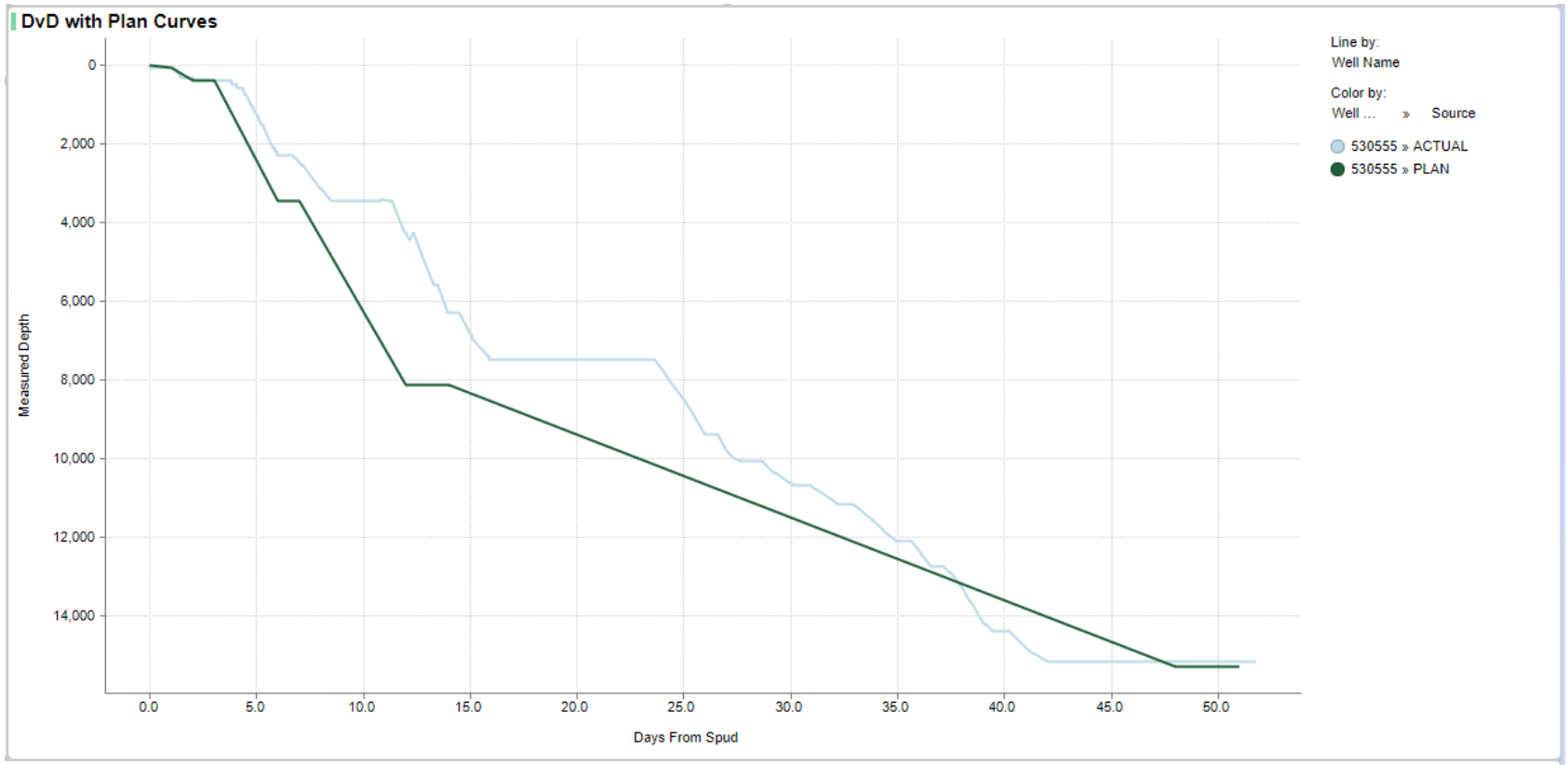
V- 530555 Basement Test Wellbore Schematic



V- 530555 Basement Test Pad and Drilling Operations

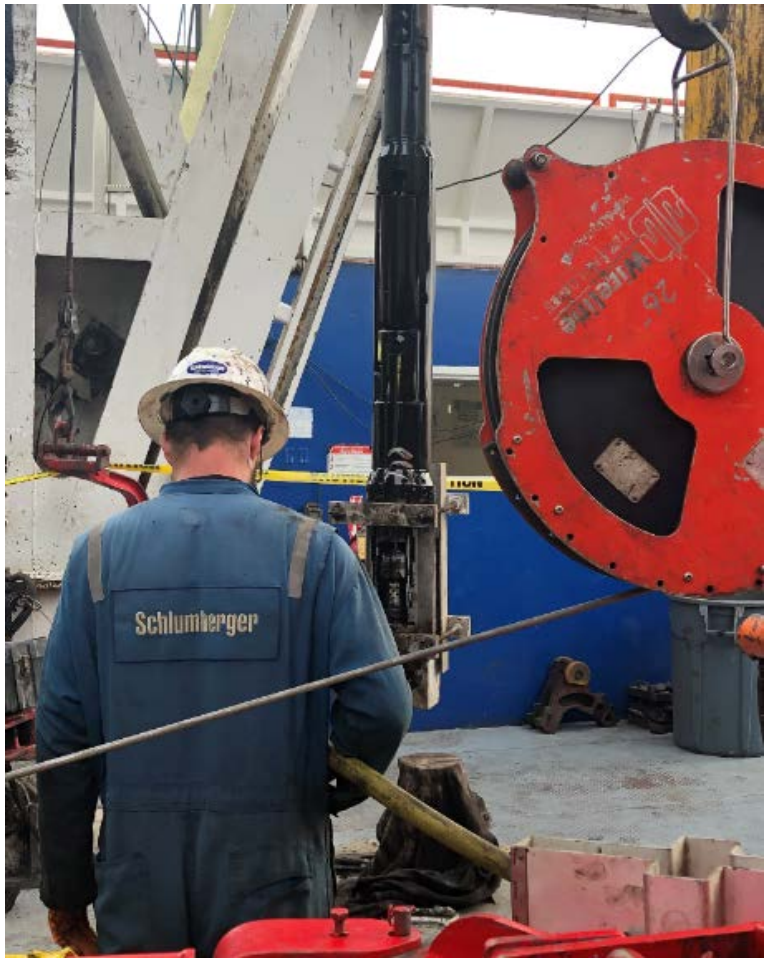


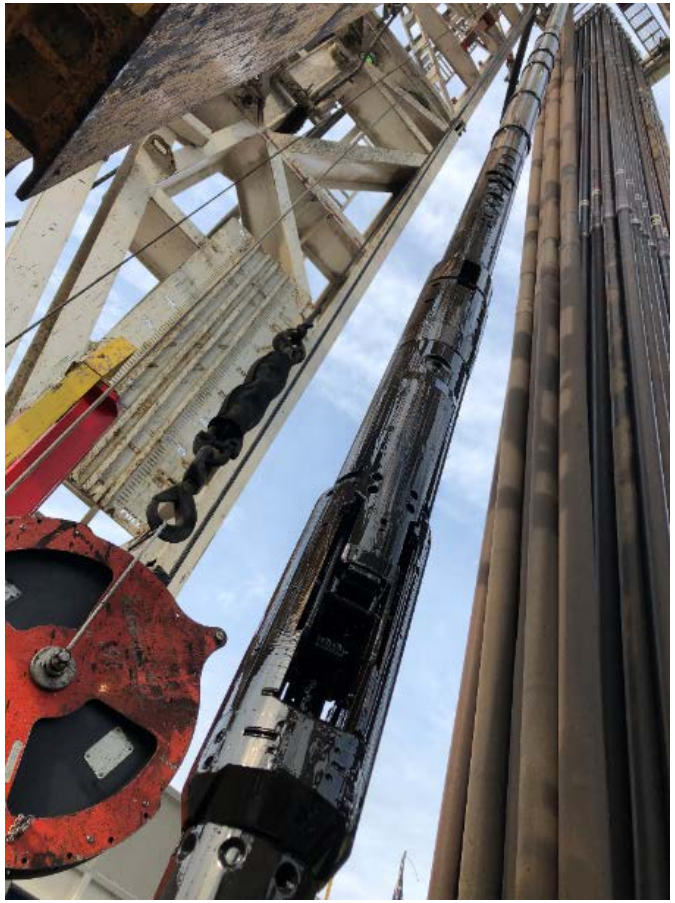
V-530555 Drilling Time Curve



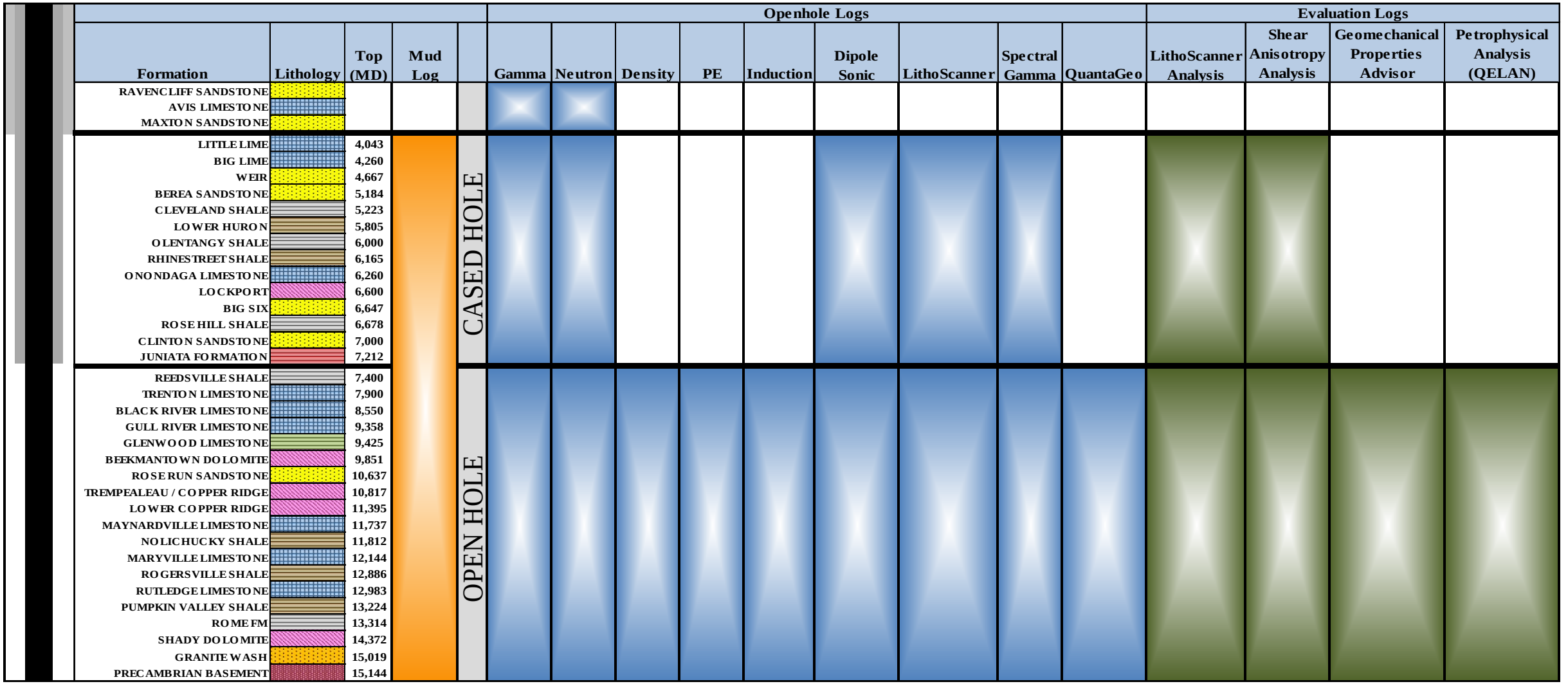
- Target of Pre-Cambrian basement for full section characterization successfully reached.
- Time required to reach target formation was less than forecasted.
  - AFE'd @ 48 days, but completed in 42 days. (Inclusive of NPT time in previous slide).
- Accurately identified and predicted geo-hazards, though some still gave us trouble
- Successfully completed operations without any injury, illness, or environmental issues.
  - Over 30,000 man hours worked

V-530555 Geological Update





Wireline and Mud Logging Data Gathered from the 530555

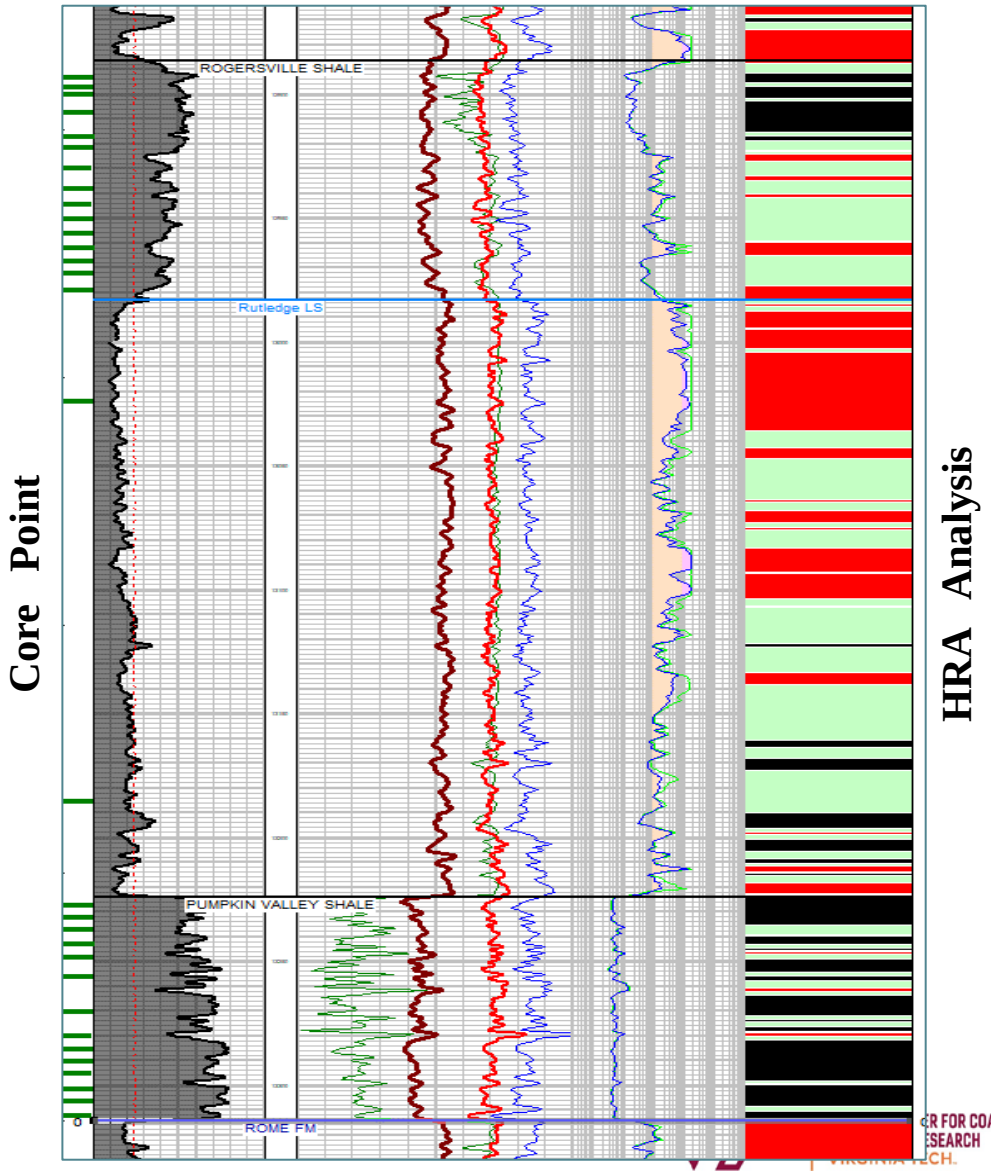


Core Point Determination

- A Heterogeneous Rock Analysis (HRA) was conducted to evaluate the variability of log responses based on Triple Combo data and identify packages (Facies) of like rock and ensure optimal distribution of the Rotary Sidewall Cores (RSWC).

- The HRA was performed on 10 individual formations of interest:

  - Trenton / Black River Ls
  - Glenwood through Rose Run
  - Nolichucky Shale
  - Maryville Limestone
  - Rogersville Shale
  - Rutledge Limestone
  - Pumpkin Valley Shale
  - Rome Fm
  - Shady Dolomite
  - Granite Wash



Coring Summary

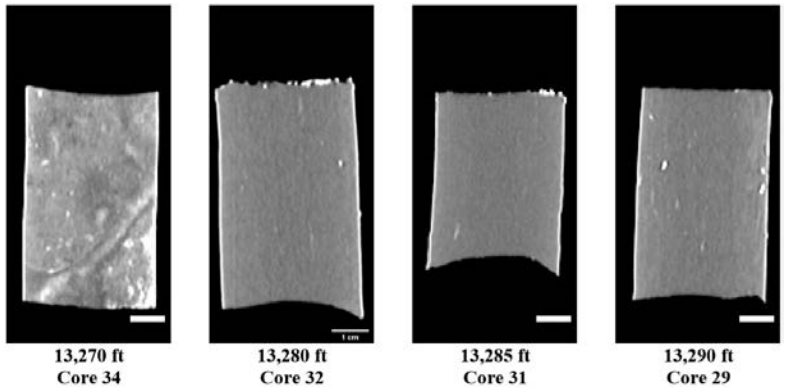
FORMATION	UNIQUE CORE POINT ATTEMPTED	UNIQUE CORE POINT RECOVERED	# OF RSWC RECOVERED	COMMENTS
REEDSVILLE	**1**	**0**	**0**	
TRENTON	**7**	**4**	**4**	
BLACK RIVER	**2**	**1**	**1**	
GLENWOOD / WELLS CREEK	**4**	**4**	**4**	
BEEKMANTOWN	**4**	**3**	**3**	
ROSE RUN	**3**	**3**	**4**	Duplicate core recovered at 10,708'
MAYNARDVILLE	**1**	**1**	**1**	
NOLICHUCKY	**7**	**4**	**4**	
MARYVILLE	**17**	**15**	**15**	
ROGERSVILLE	**16**	**16**	**16**	
RUTLEDGE	**2**	**2**	**2**	
PUMPKIN VALLEY	**16**	**15**	**17**	Duplicate core recovered at 13,306' & 13,312'
ROME	**9**	**7**	**7**	
SHADY DOLOMITE	**9**	**8**	**8**	
GRANITE WASH	**4**	**4**	**4**	
TOTAL	**102**	**87**	**90**	

RECOVERY RATE: **85%**

CT Scanning National Energy Technology Laboratory (NETL)

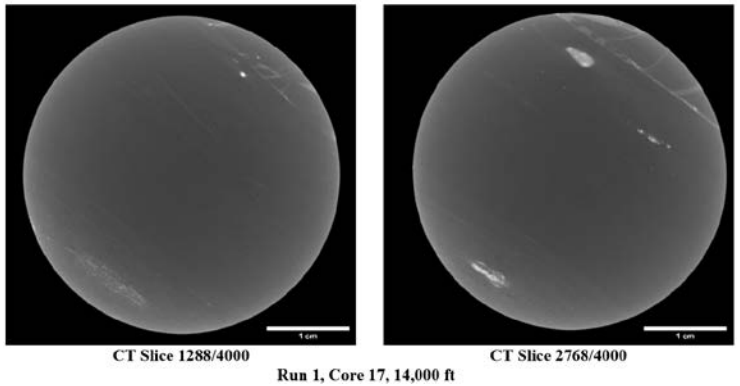
work led by Dustin Crandall, NETL

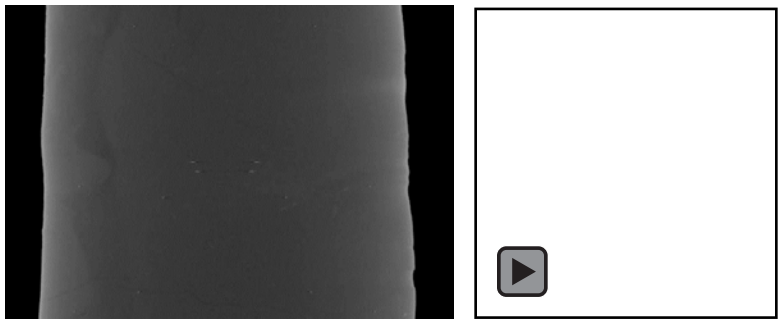
- All 90 cores were scanned utilizing a Medical CT Scanner
  - Each core was scanned at two energies so that the dual energy density could be calculated



Grouping of Pumpkin Valley Shale scans. Scale bar: 1 cm

- 11 cores were selected to be scanned at high resolution with the Industrial CT Scanner
  - Additional cores can be scanned at high resolution if desired but was limited initially





Rome Fm scans. Scan resolution : 17.5 um& Scale bar: 1 cm

Logging, Coring, and Analysis

Logging Job 1 (Intermediate Section)

- Quad Combo (G, N, D, Pe, LL)
- Dipole Sonic
- LithoScanner
- ELAN (Shale Evaluation)
- Mechanical Properties

Logging Job 2 (Deep Section)

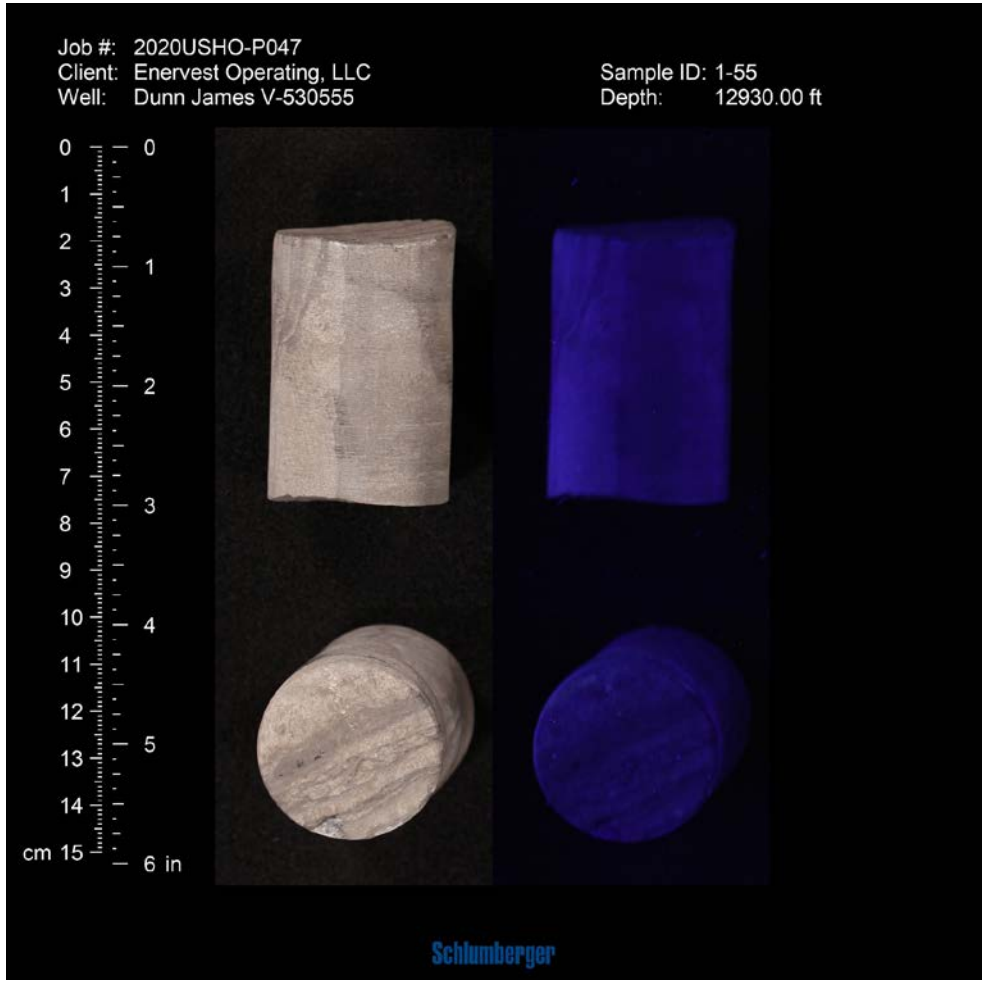
- Quad Combo (G, N, D, Pe, LL)
- Dipole Sonic
- LithoScanner
- FMI / OBMI
- ELAN (Shale Evaluation)
- Mechanical Properties

Coring Operations (Deep Section)

- 90 RSWC (XL-Rock – 1 ½” x 3”) wereretrieved

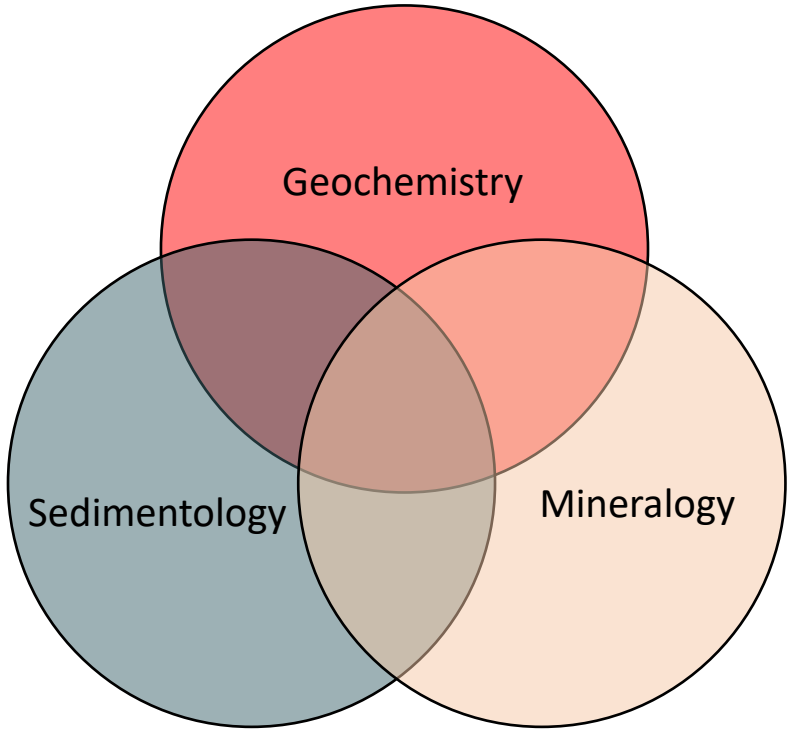
Core Analysis (Deep Section)

- Source Rock Analysis (SRA)
- Tight Rock Analysis (TRA) Porosity
- Tight Rock Analysis (TRA) Pressure Decay Permeability
- X-ray Diffraction Analysis (XRD)
- Scanning Electron Microscopy (SEM)
- X-ray CT Scanning - VT
- Adsorption Isotherms (CH_4, N_2, CO_2) - VT
- Desorption Isotherms (CH_4, N_2, CO_2) - VT
- Capillary Suction Clay Dispersion Analysis (CST)
- Proppant Embedment Test / Fracture Conductivity Analysis
- Multi Stress Compression Test



Sedimentology and Geochemistry Research
led by Dr. Ben Gill in Geosciences

- Conduct geochemical, sedimentological, and mineralogical examination of the the Conasauga Shale units: Nolichucky, Rogersville, Pumpkin Valley Shales.
- Determine environmental controls on organic matter deposition in the Conasauga Shale units: Nolichucky, Rogersville, Pumpkin Valley
- Characterize post-depositional processes that may effect source rock quality
- Establish a model for organic matter deposition in the Rome Trough



Sedimentology and Geochemistry

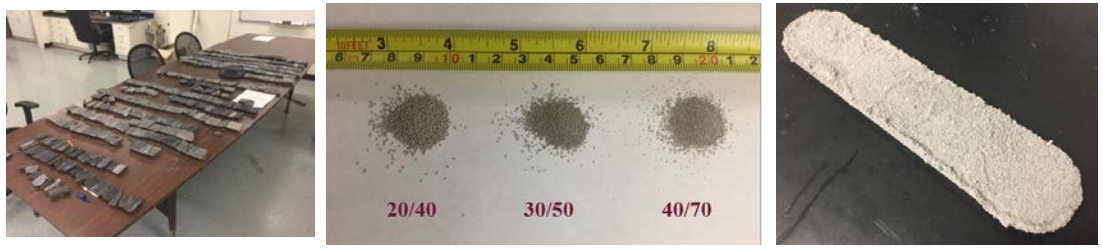
Analysis	Environmental conditions/processes	Progress
TOC, pyrite S, Organic sulfur contents	Source rock quality; diagenetic processes	TOC analysis completed on the cuttings from deep Cambrian Shales. SLB and VT Core Analysis
Carbon isotopes ($\delta^{13}C$)	Organic matter source and quality/alteration, well correlation	Completed on the cuttings from deep Cambrian Shales
Iron speciation	Local redox chemistry during deposition/early diagenesis	TBD
Redox sensitive trace metals (Mo, U, V)	Local redox chemistry during deposition/early diagenesis	TBD
Major elements (Al, Si, Ti, etc.)	Sediment source	TBD
Sedimentology	Sediment transport, diagenetic depositional processes; bioturbation	Thin section analyses started
Mineralogy	Sediment source; diagenetic processes	SLB Core Analysis


ESUP Site
Bloomer Outcrop
Kingsport
Pumpkin Valley Shale
Rutledge Limestone
Rogersville Shale
Maryville Limestone
31
Bert Bloomer Rd
© 2020 Google
68 m
Google Earth

Pumpkin Valley – Rutledge Transition

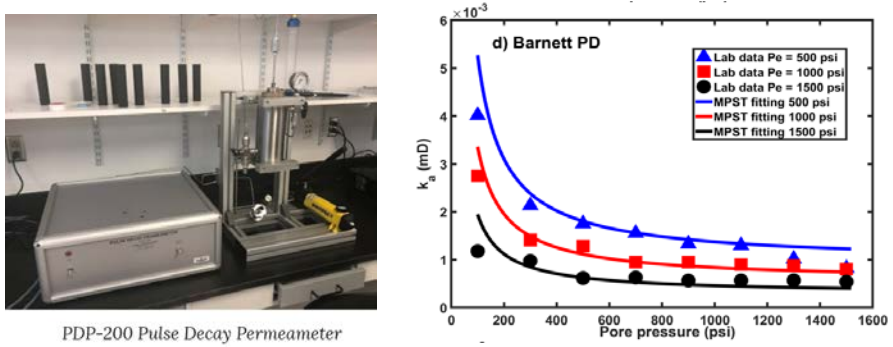
Core Analysis and Modeling

Led by Dr. Cheng Chen, Mining Engineering

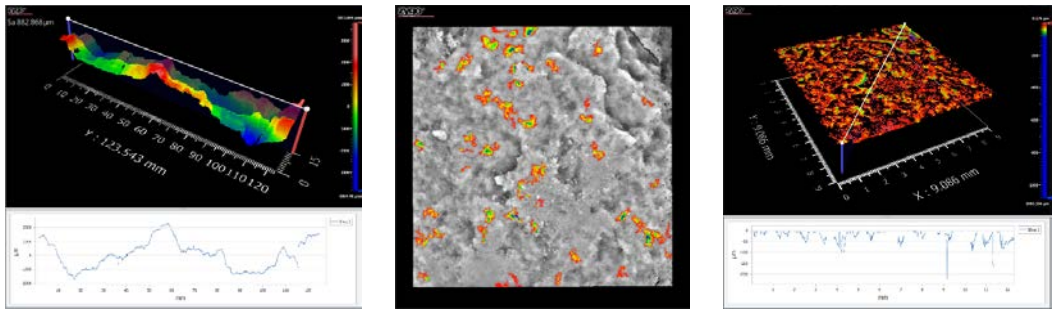


1. Shale sample sorting from the field based on the depth, and the performance testing of proppant in different sizes

2. Conductivity curve as a function of closure pressure in the non-smooth-surface shale sample



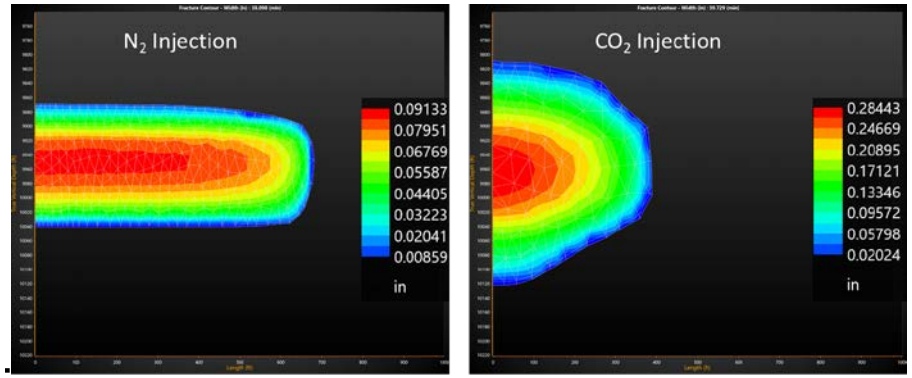
3. PDP permeability measurement for the shale samples from different formations, and a multi-physics shale transport model (MPST) developed using PDP data (published at Li et al 2020, *JPSE*)

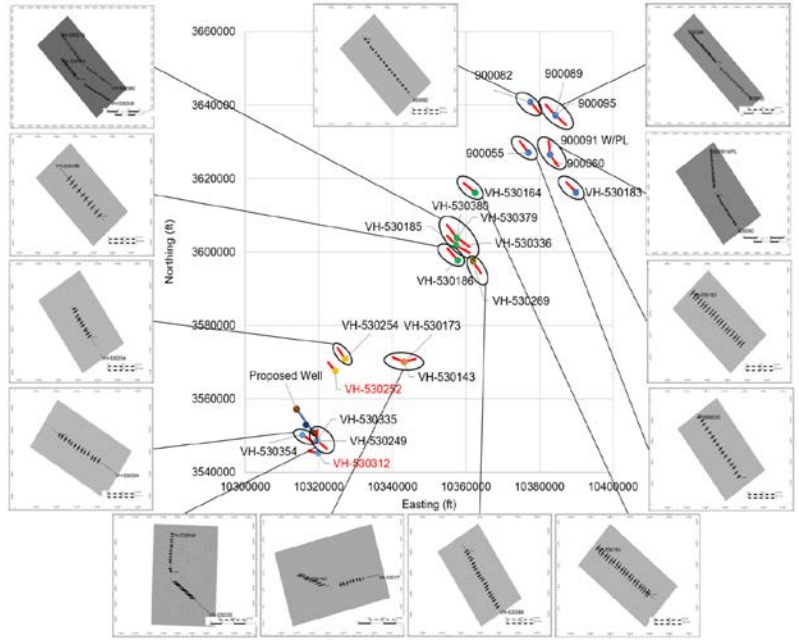


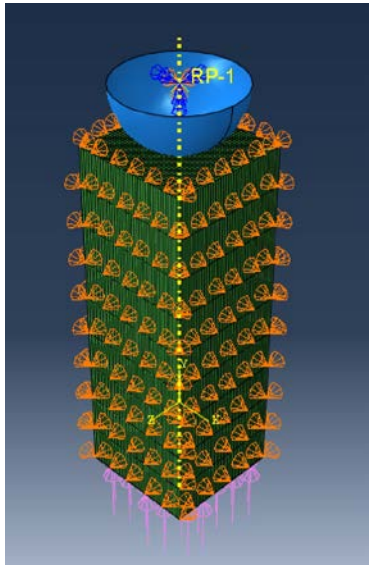
4. Shale sample non-smooth-surface stitch scanned by profilometer

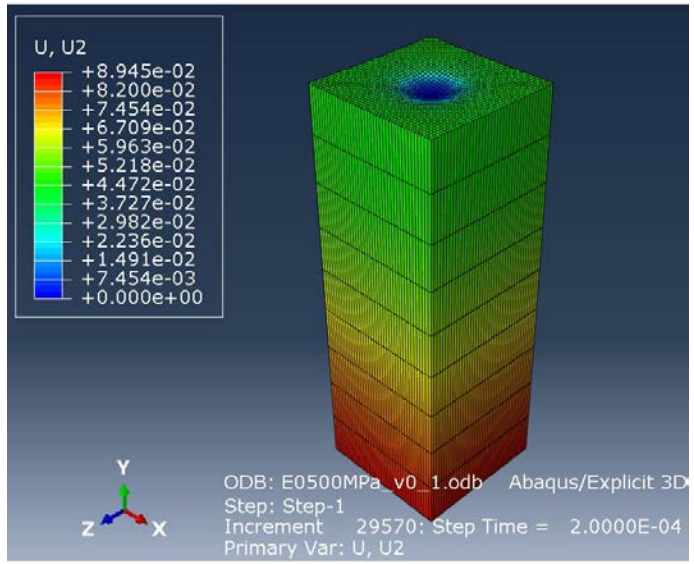
Modeling Tools and Approaches
led by Dr. Cidgem Keles

- CMG
  - Field scale reservoir simulator
  - Finite difference formulation
- ABAQUS, XFEM
  - Finite element formulation
  - Hydraulic fracturing modeling
  - Proppant embedment
- Phase behavior model
  - In-house Equation of State flash calculation
- In house fully compositional simulation model









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Dissemination of Results

- Advisory Stakeholder Group includes community leaders
- Local outreach events completed, and future ones planed
- Multiple press releases by DOE and VT
- Project Website: www.esup.energy.vt.edu
- 1 MS and 1 PhD Degree completed
- 1 MS and 2 PhD Degrees in progress
- Multiple journal and conference publications

Summary

- 2nd deepest well drilled in Virginia
- Well Logs and Core obtained from reservoirs of interest
- Core and log analysis on-going
- Formation Testing Planned (DFIT)
- BP3 Plans
  - Core Analysis
  - Geologic Characterization
  - Reservoir Modeling
  - Data Analysis
  - Commercialization Plans

Contacts

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