"Big Data" Empowering Unconventional Resource Plays*

Timothy Carr[1], Maneesh Sharma[1], and Frank LaFone[1]

Search and Discovery Article #41703 (2015)**
Posted November 2, 2015

*Adapted from oral presentation given at AAPG Annual Convention & Exhibition, Denver, Colorado, May 31-June 3, 2015

[1]Geology and Geography, West Virginia University, Morgantown, West Virginia (tim.carr@mail.wvu.edu)

Abstract

Since its inception data has been the basis of the petroleum industry. Oil and gas exploration and development has always been about knowing where to look and where exactly to drill. Oil and gas geosciences have been pursing big data before "big data" was big. In the first decade of the 21st Century, "big data" burst upon the scene, while horizontal drilling and fracture stimulation have been around for decades. What has created successful exploration and development of unconventional resources is smart exploration, drilling and completion. Integrated geologic and geophysical analysis provides the map that lets one know where to drill, while down-hole real-time sensors tell one where to steer the well within the correct zone. The latest technologies of micro-seismic and fiber-optics tell one where and how to complete. The bottom line is that a drilling rig has become a mass of sensors and computers with a drill bit attached to one end.

Increased usage in subsurface geology of data from sensors and operational data gathering devices has significantly increased the amount of unstructured data. Oil and gas has long handled massive volumes of structured data such as 3D seismic - what is the new challenge is development of tools to handle new types of unstructured data or to integrate diverse structured and unstructured data sets from diverse geologic disciplines. Exploration and development of unconventional resources requires integration of "big data" within traditional models and approaches to geologic analysis. We provide several examples from the Marcellus and Utica mudrock plays of the northern Appalachian Basin to illustrate low-cost technologies to store, query, and analyze large and diverse data sources and new data types much of which is found outside of the company's firewall. Integration involving more diverse unstructured, semi-structured and structured data can lead to a better understanding of unconventional resource plays and provide predictive exploration and development models for unconventional resources that often span multiple countries, states and hundreds of kilometers.

"BIG DATA" EMPOWERING UNCONVENTIONAL RESOURCE PLAYS

Timothy R Carr, Maneesh Sharma and Frank LaFone

Tim Carr
Phone: 304.293.9660
Email: tim.carr@mail.wvu.edu

MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY
MSEEL

The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a long-term collaborative field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development

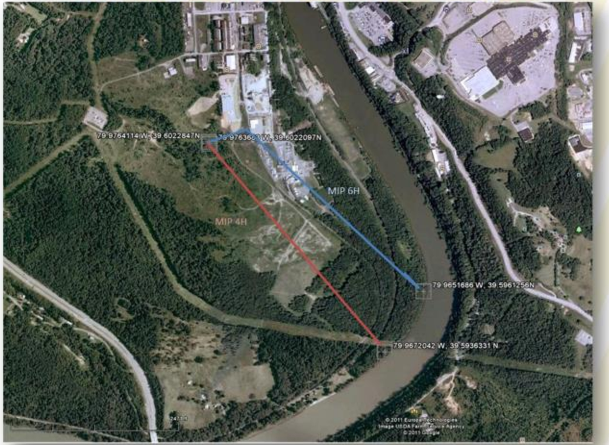
AGENDA

- Overview of MSEEL Collaboration
  - Multi-Institutions (Private Enterprise, Public Intuitions, NGOs)
  - Multiple Events
  - Industry – Northeast Natural Energy, LLC
- MSEEL Technical Plan
  - **Data Management**
  - Surface Water/Cuttings Sampling
  - Fluids & Gas
  - Air & Noise Stations
  - Core & Sidewall Core Sampling
  - Logging
  - Microseismic/Fiber Optics
  - Social / Economic
  - Drilling and Completion
- Challenge of Data Management
  - Multi-Institutional
  - Volume – Variety – Velocity

MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY - MSEEL

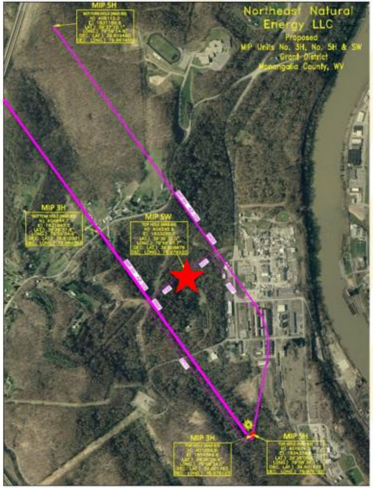
NORTHEAST NATURAL ENERGY
MIPU 4H AND 6H - 2011

NORTHEAST NATURAL ENERGY
MIPU 4H AND 6H - 2011



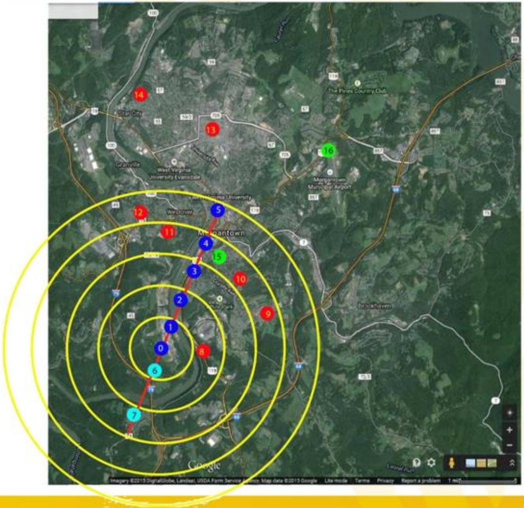
Presenter's notes: In the summer months (no heating load) ranges from 2000 mcf to 6000 mcf per day. On a peak winter day the usage is between 35,000 mcf and 45,000 mcf per day.

MSEEL WELL PROJECT - 2015



- Time-Line
  - Base-Line Studies: Ongoing
  - Drill Top Holes: July
  - Drill Science Well: August
  - Design Initial Production Well Completions
  - Drill Production Wells: October
  - Completions: November
  - Production Monitoring
- Analysis 2016-2018
- Drilling of Additional Wells
  - 2018?

Environmental Monitoring



Location of Air Sampling Stations

Navy dots – WVU Downwind in-valley transit from well site.

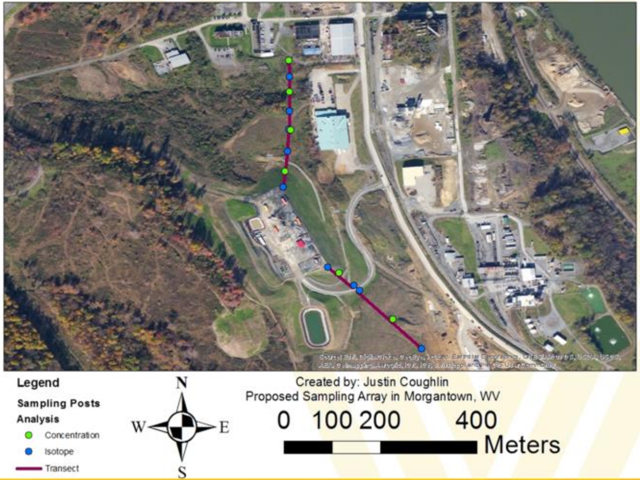
Cyan dots – WVU Upwind in-valley transit from well site.

Red dots – WVU background/traffic-only source air sites

Green dots – WVDEP sampling sites

Yellow Circles are half mile incremental radii centered on the well pad.

Environmental Monitoring

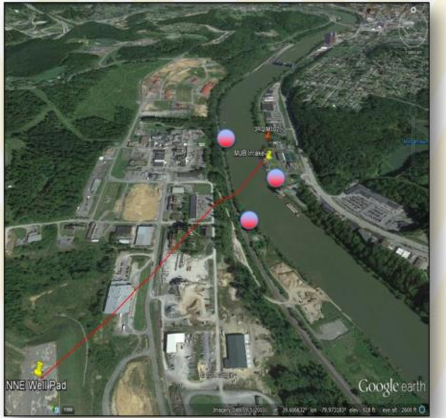


Area Noise Monitoring

- Noise Monitors
  - Pad
  - Perimeter
- Power Source

Surface Water, Liquid, Solid Waste Sampling

- Parameters: Inorganic/organic/NORM
- Baseline Monongahela River- Compare to historic record
- Drilling-cuttings/mud/flowback precipitates
- Completion-Flowback
- Production-Produced water
- Coordination with NNE, NETL, OSU, USGS and other researchers
- Sampling Schedule



CORES
VERTICAL WELL

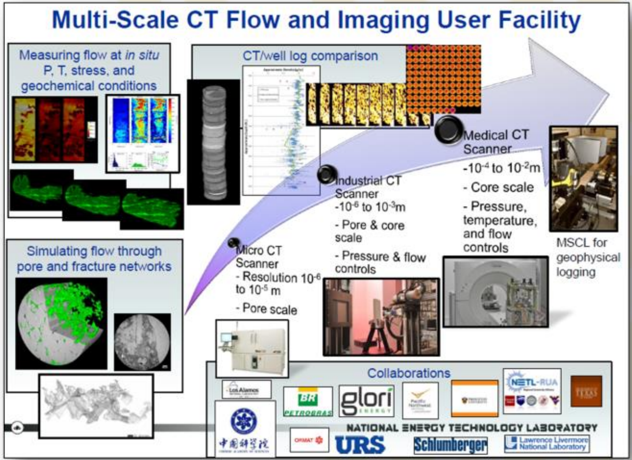
Sidewall Cores

- 50 - 2.5” X 1.5” cores
- 50 - 2” X 1” cores

Whole Core

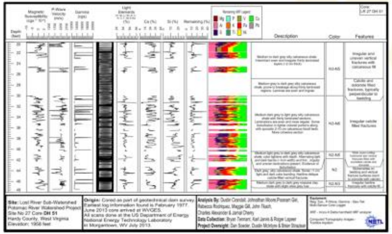
- 120’ – 4” Core
- Above, Through and Below Marcellus

WHOLE CORE


Multi-Scale CT Flow and Imaging User Facility
Measuring flow at in situ P, T, stress, and geochemical conditions
CT/well log comparison
Simulating flow through pore and fracture networks
Micro CT Scanner
- Resolution 10-6 to 10-5 m
- Pore scale
Industrial CT Scanner
-10-6 to 10-3m
- Pore & core scale
- Pressure & flow controls
Medical CT Scanner
-10-4 to 10-2m
- Core scale
- Pressure, temperature, and flow controls
MSCL for geophysical logging
Collaborations
Los Alamos
BR PETROBRAS
glori ENERGY
NETL-RUA
中国科学院
ORMAT
URS
NATIONAL ENERGY TECHNOLOGY LABORATORY
Schlumberger
Lawrence Livermore National Laboratory

MULTI-SENSOR CORE LOGGER

Geotek Multi-sensor Core Logging unit

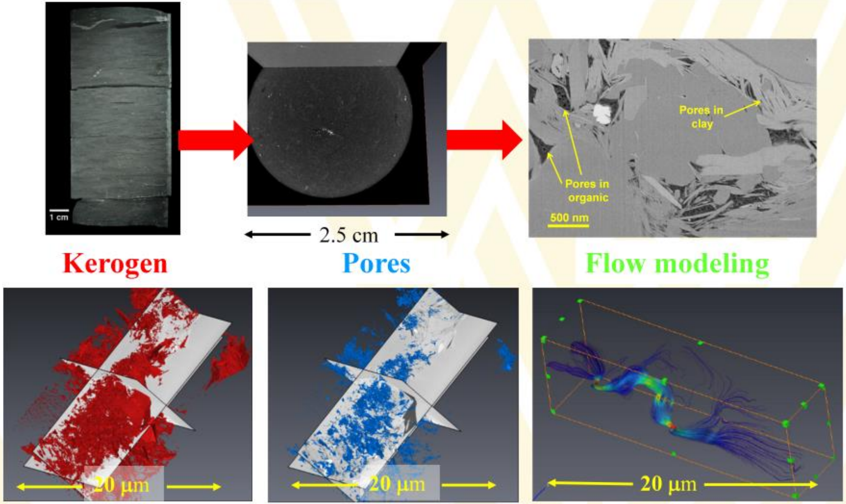


- The NETL logger is able to rapidly obtain high-resolution data including
  - p-wave velocity
  - gamma-density
  - natural gamma, resistivity
  - magnetic susceptibility
  - X-ray fluorescence spectrophotometry

on whole-round or split core samples

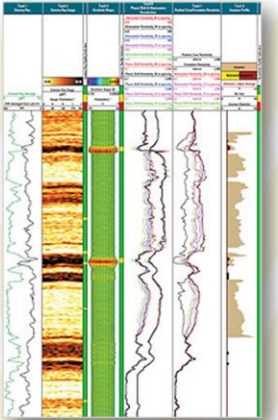
Precision Petrophysical Analysis Laboratory

Direct Imaging Across Many Length Scales: Utica Shale

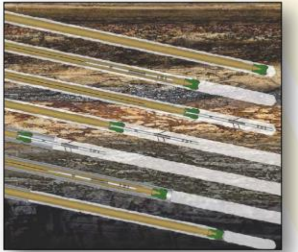


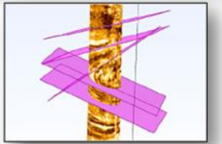
LOGGING VERTICAL WELL

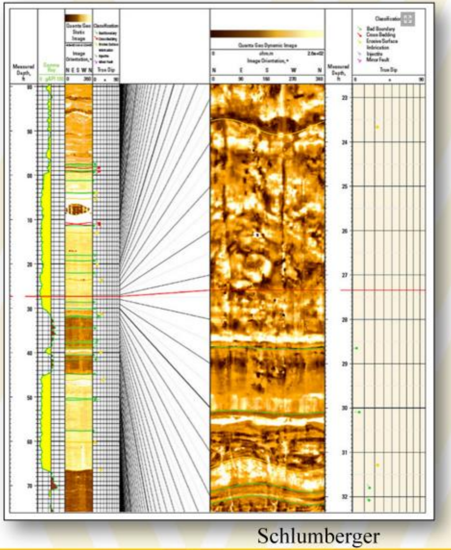
- Full-bore Micro Imager [sw]
- MDT stress [sw]
- Dielectric Permittivity [sw]
- Magnetic Resonance [sw]
- Reservoir Saturation Tool [sw]
- Quanta-Geo Imaging
- Litho Scanner



MSEEL
LOGGING LATERAL

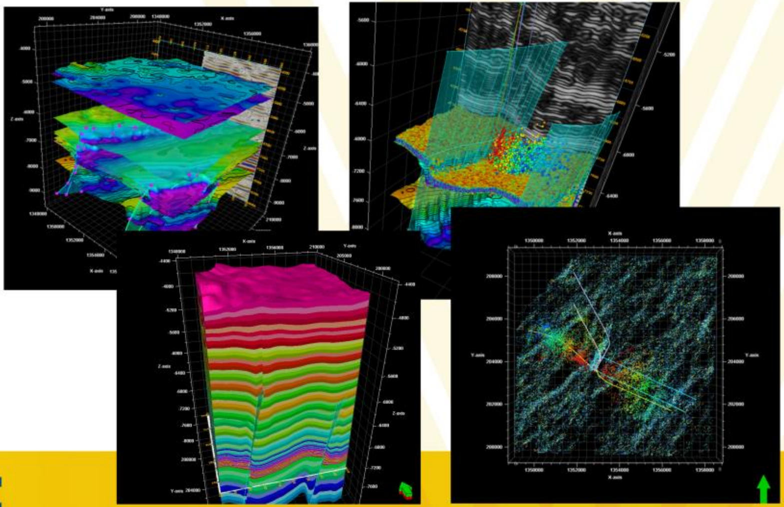




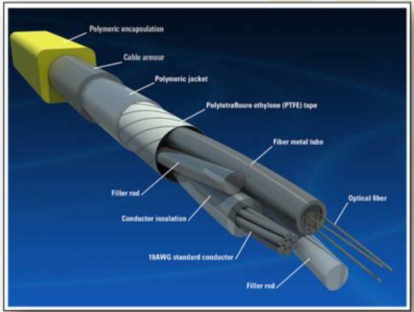


Presenter's notes: Drilling-induced fractures are clearly visible as linear or curvilinear subvertical features at approximately N45E and S45W in the expanded-scale dynamic image from Quanta Geo photorealistic reservoir geology service in Track 5. The well's intersection of this channel sand close to its axis makes many of the scour features appear flattened, which would render them unrecognizable on a conventional OBM-adapted image. The dipping portion of a basal scour interpreted at 31.3 ft suggests that the axis of deposition is N20E-S20W. The scour is filled by a 1-ft-thick lower-energy deposit. Scour features identified higher in the section indicate that paleo-transport shifted to a NW-SE axis.

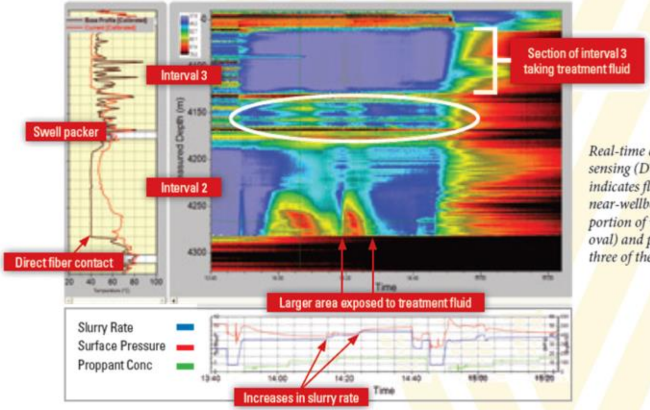
SOME MICROSEISMIC PERSPECTIVES FOR THE MORGANTOWN MSEEL SITE



FIBER-OPTICS



FIBER-OPTICS DISTRIBUTED TEMPERATURE SENSING



Real-time distributed temperature sensing (DTS) StimWatch service indicates fluid movement in the near-wellbore, under-stimulated portion of wellbore interval (white oval) and packer leak during stage three of the fracture treatment.

BIG DATA CHALLENGES

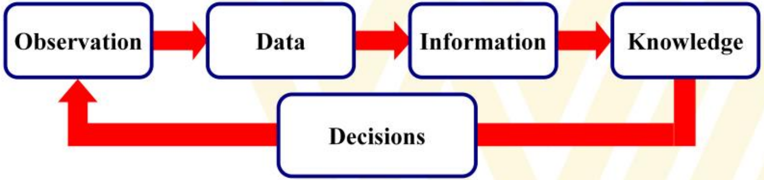
- All-encompassing term for any collection of data sets so large, unstructured and complex that it becomes difficult to process using traditional data processing applications.
- Challenges
  - Capture
  - Analysis and Visualization
  - Curation
  - Query(Search)
  - Sharing
  - Storage
  - Transfer
  - Privacy
- Differs from "Traditional Geosciences"

A visualization created by IBM of Wikipedia edits. At multiple terabytes in size, the text and images of Wikipedia are a classic example of big data.

BIG DATA IN SCIENCE AND RESEARCH

- When the Sloan Digital Sky Survey (SDSS) began collecting astronomical data in 2000, it amassed more in its first few weeks than all data collected in the history of astronomy. Continuing at a rate of about 200 GB per night, SDSS has amassed more than 140 terabytes of information.
- When the Large Synoptic Survey Telescope, successor to SDSS, comes online in 2016 it is anticipated to acquire that amount of data every five days.
- Decoding the human genome originally took 10 years to process, now it can be achieved in less than a day: the DNA sequencers have divided the sequencing cost by 10,000 in the last ten years, which is 100 times cheaper than the reduction in cost predicted by Moore's Law.
- The NASA Center for Climate Simulation (NCCS) stores 32 petabytes of climate observations and simulations on the Discover supercomputing cluster.

BIG DATA CHALLENGES IN APPLIED RESEARCH PROCESS



- Sharing Exponentially Increasing Amounts of Data
  - Heterogeneity of data, software and hardware
- Lack of Tools Dealing with Voluminous Data Sets
  - Organizing, Storing, Preserving, Retrieving, Browsing, Processing & Visualization
- Need for Time Critical Learning
  - Temporally Obsolete Knowledge for Time-Critical Applications
  - Allocation of Computational and Networking Resources
- Conduct Analyses at Regional to Global Spatial Scales
- Curation of Data and Preservation of Scientific Analyses
- Learning Process as a Collaborative Process
  - Teams, Agencies, Communities & States

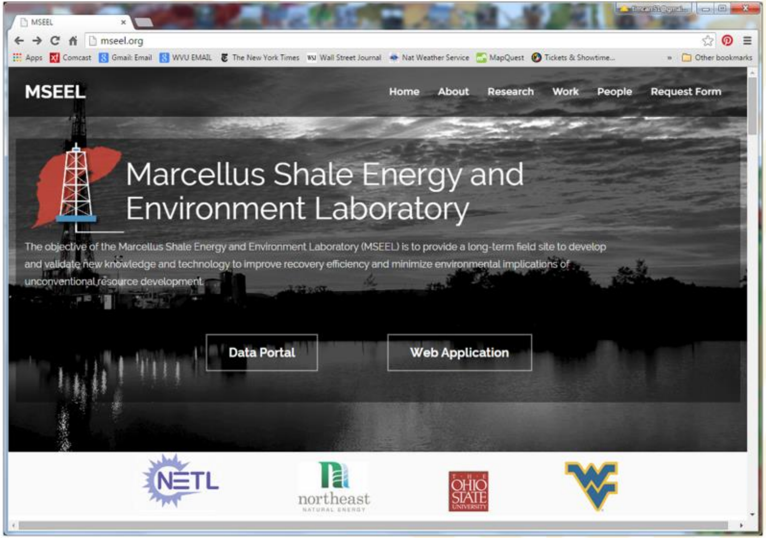
CYBERINFRASTRUCTURE OVER-ARCHING GOALS

- Connection
  - Bring Together Groups with Possible Solutions
  - Complete Digital Access to Information & Tools
    - Expert, Decision Maker, General Public
- Complexity
  - Harder to Display
  - Harder to Analyze (Integrate Data with Models)
  - Harder to Manage
- Coordination
  - Bring the Players Together
  - Bring the Data Together

Provide Technical & Scientific Basis for Decisions

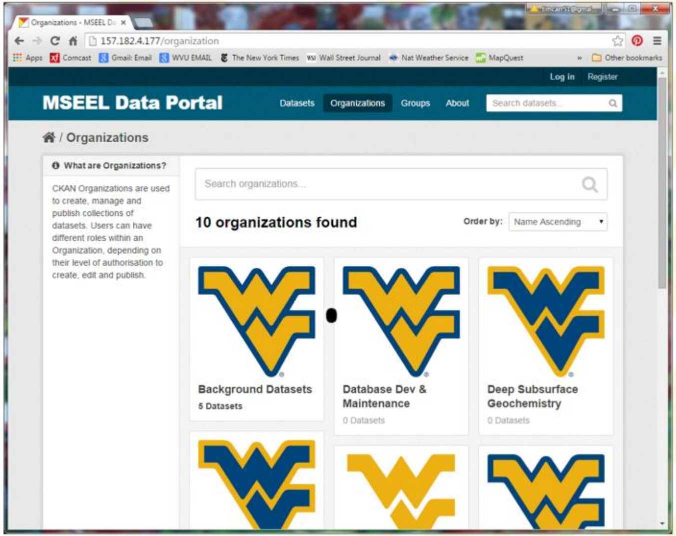
MSEEL DATA VISION

- Develop a robust and validated analysis platform to deploy in-place (real time) analytics in the planning drilling and operations of shale gas wells.
- Big Data
  - Volume
  - Variety
  - Velocity
- Potential for Data-Base Innovation
  - Advanced Logging
  - Microseismic Monitoring
  - Fiber-Optic Monitoring
  - Surface Monitoring
  - Societal Impacts
- Real-Time Optimization
  - Fracture Stimulation
- Develop New Scientific and Engineering Approaches to Apply to Multi-Disciplinary and Multi-institutional Natural Resource Studies

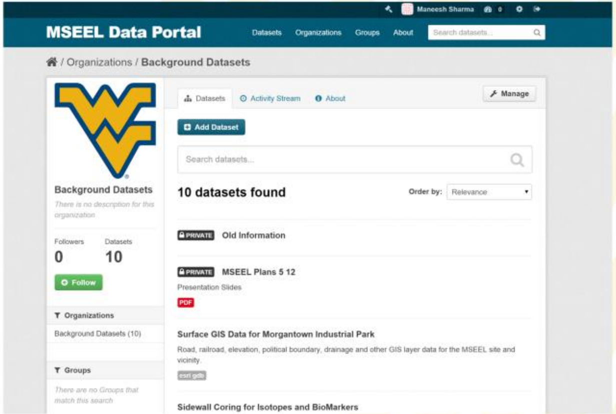

MSEEL
mseel.org
Apps Comcast Gmail: Email WVU EMAIL The New York Times Wall Street Journal Nat Weather Service MapQuest Tickets & Showtime... Other bookmarks
MSEEL
Home About Research Work People Request Form
Marcellus Shale Energy and Environment Laboratory
The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a long-term field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development.
Data Portal
Web Application
NETL
northeast NATURAL ENERGY
THE OHIO STATE UNIVERSITY

MSEEL DATA PORTAL

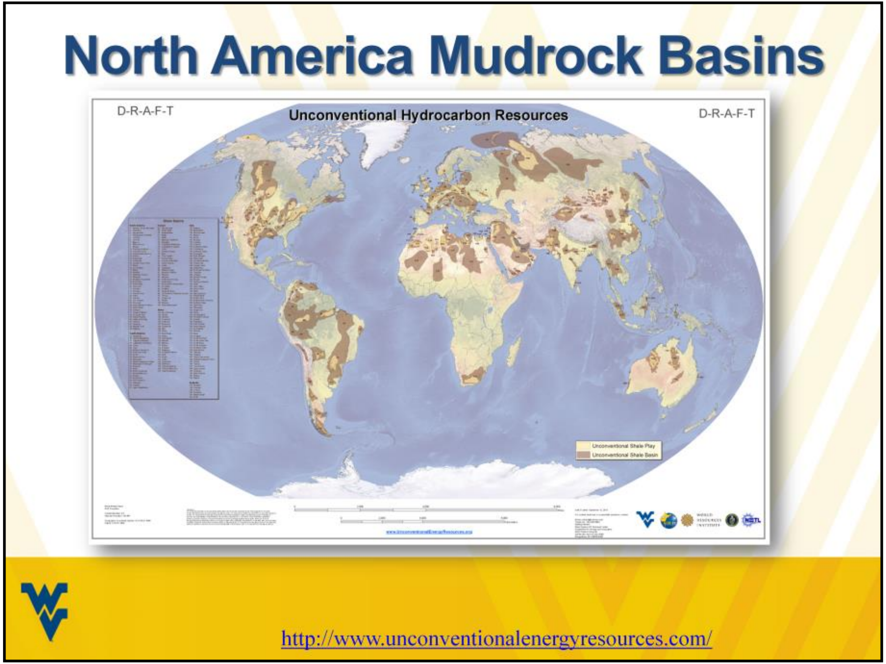
- Data portal will serve as central place to exchange and search for data
- **CKAN** - Open source data portal software (www.ckan.org) will be used
  - EDX and Data.gov among several agencies use the same platform
  - Data Portal Features
    - Publish and find datasets
    - Store and manage data
    - Private Workspaces and Federate
      - Store raw data and metadata
      - Add data directly through web interface
      - Harvesting – Using same data portal will allow to search data in different federal databases
      - Search and Discovery
      - Search and Display Geospatial Data


Organizations - MSEEL D...
157.182.4.177/organization
Apps Comcast Gmail: Email WVU EMAIL The New York Times Wall Street Journal Nat Weather Service MapQuest Other bookmarks
Log in Register
MSEEL Data Portal
Datasets Organizations Groups About
Search datasets...
/ Organizations
What are Organizations?
CKAN Organizations are used to create, manage and publish collections of datasets. Users can have different roles within an Organization, depending on their level of authorisation to create, edit and publish.
Search organizations...
10 organizations found
Order by: Name Ascending
Background Datasets
5 Datasets
Database Dev & Maintenance
0 Datasets
Deep Subsurface Geochemistry
0 Datasets

PUBLIC VS. PRIVATE

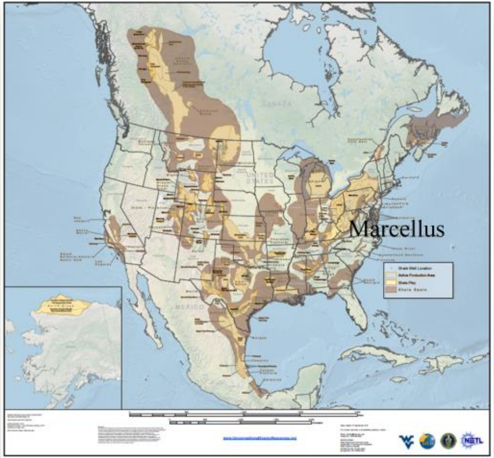


DEVICE INDEPENDENT



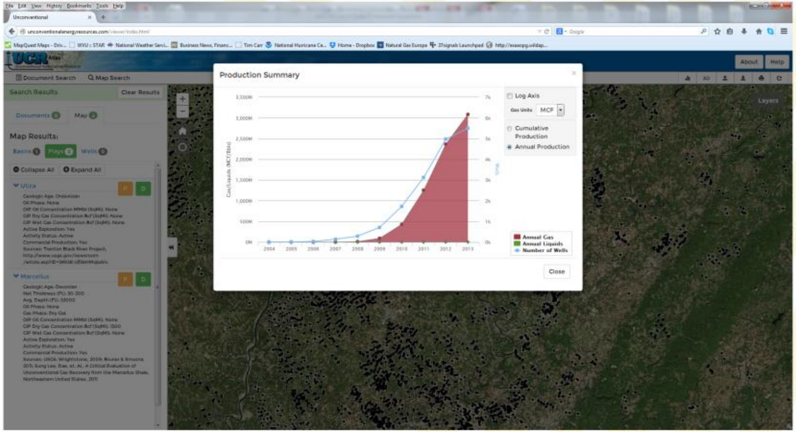
Presenter's notes: North America shale basins showing the location of active and potential unconventional oil and gas "shale" plays. Active shale gas and oil plays that have been assessed as part of a study funded in part by the National Energy Technology Laboratory of the US Department of Energy are highlighted. Active areas of the Utica and Marcellus shale plays are labeled. Information is available online at (http://www.unconventionalenergyresources.com/). (Web accessed September 9, 2015)

North America Mudrock Basins



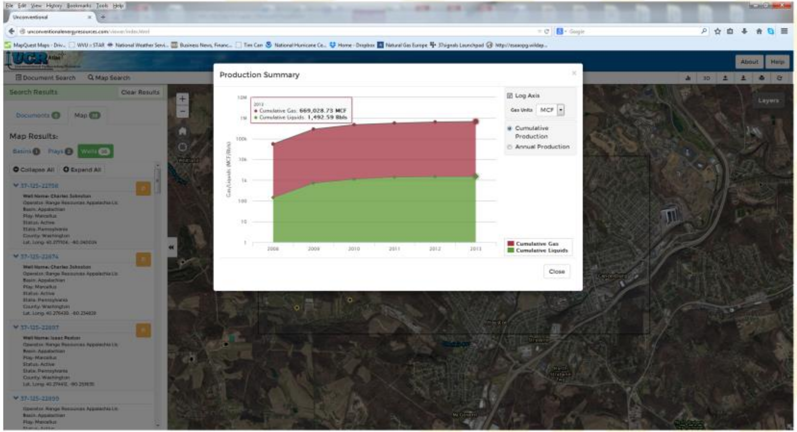
http://www.unconventionalenergyresources.com/

North America Mudrock Basins

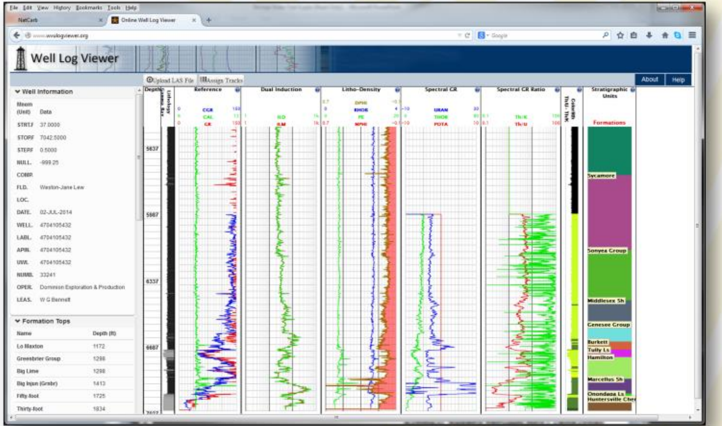


http://www.unconventionalenergyresources.com/

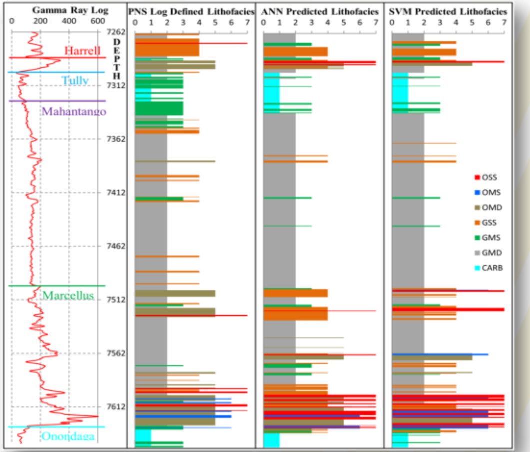
North America Mudrock Basins



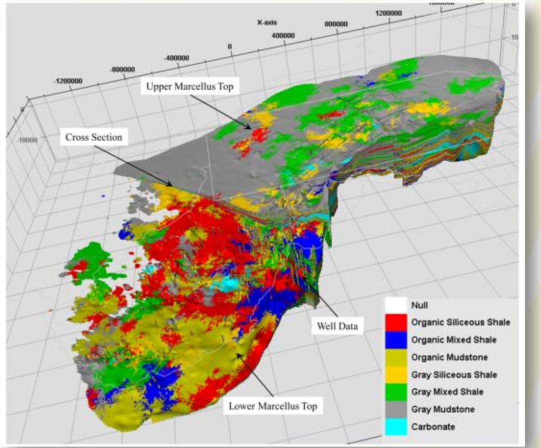
US Regional Projects – Data Viewer



LITHOFACIES IDENTIFICATION



LITHOFACIES 3D MODELING

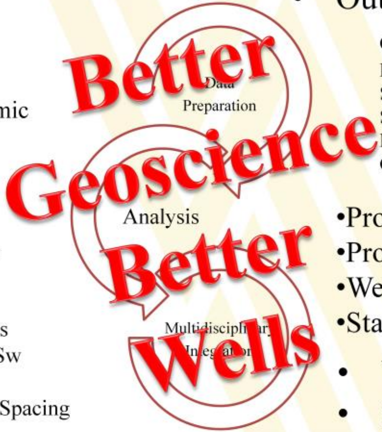


Wang and Carr

Presenter's notes: Marcellus Shale lithofacies 3D model by sequential indicator simulation algorithm: (a) Top of Otaka Creek Member in 3D view; (b) Top of Union Spring Member in 3D view; (c) cross sections; (d) fence diagram zoomed into Pennsylvania and north West Virginia.

GEOSCIENCE WORKFLOW

- Inputs
  - Core
  - Seismic
  - Microseismic
  - Logs

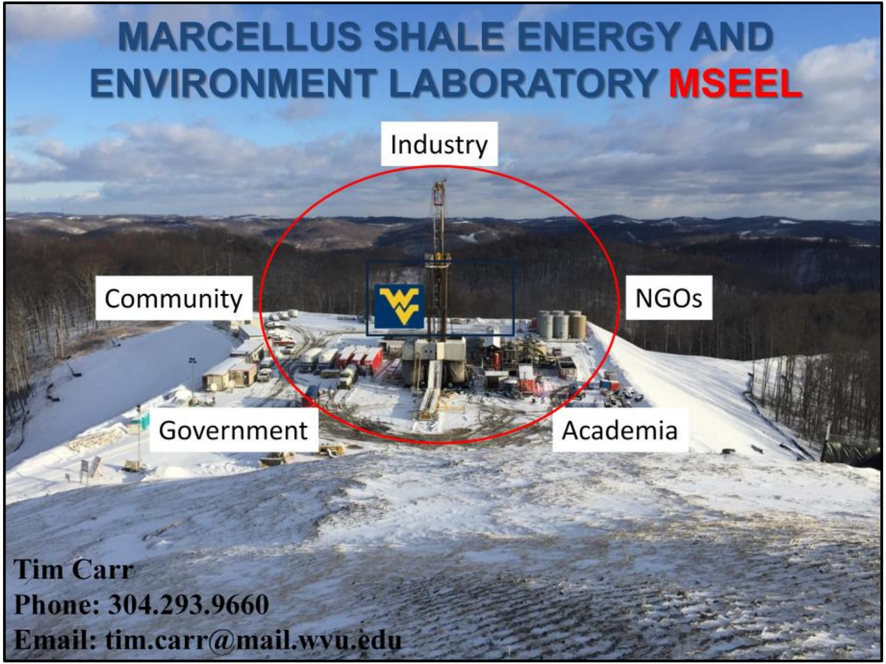


- Volumes
- Structure -Faults
- Mineralogy
- Geomechanical
- Organic Richness
- Porosity, Perm, Sw
- Well Path
- Stage & Cluster Spacing

- Outputs
  - Organic Richness
  - Porosity & Permeability, Sw
  - Structure - Faults
  - Saturations
  - Mineralogy
  - Geomechanical Properties

- Production Volumes
- Production Trends
- Well Path
- Stage & Cluster Spacing
- Well Production
- Sensitivity

MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY MSEEL



Tim Carr
Phone: 304.293.9660
Email: tim.carr@mail.wvu.edu