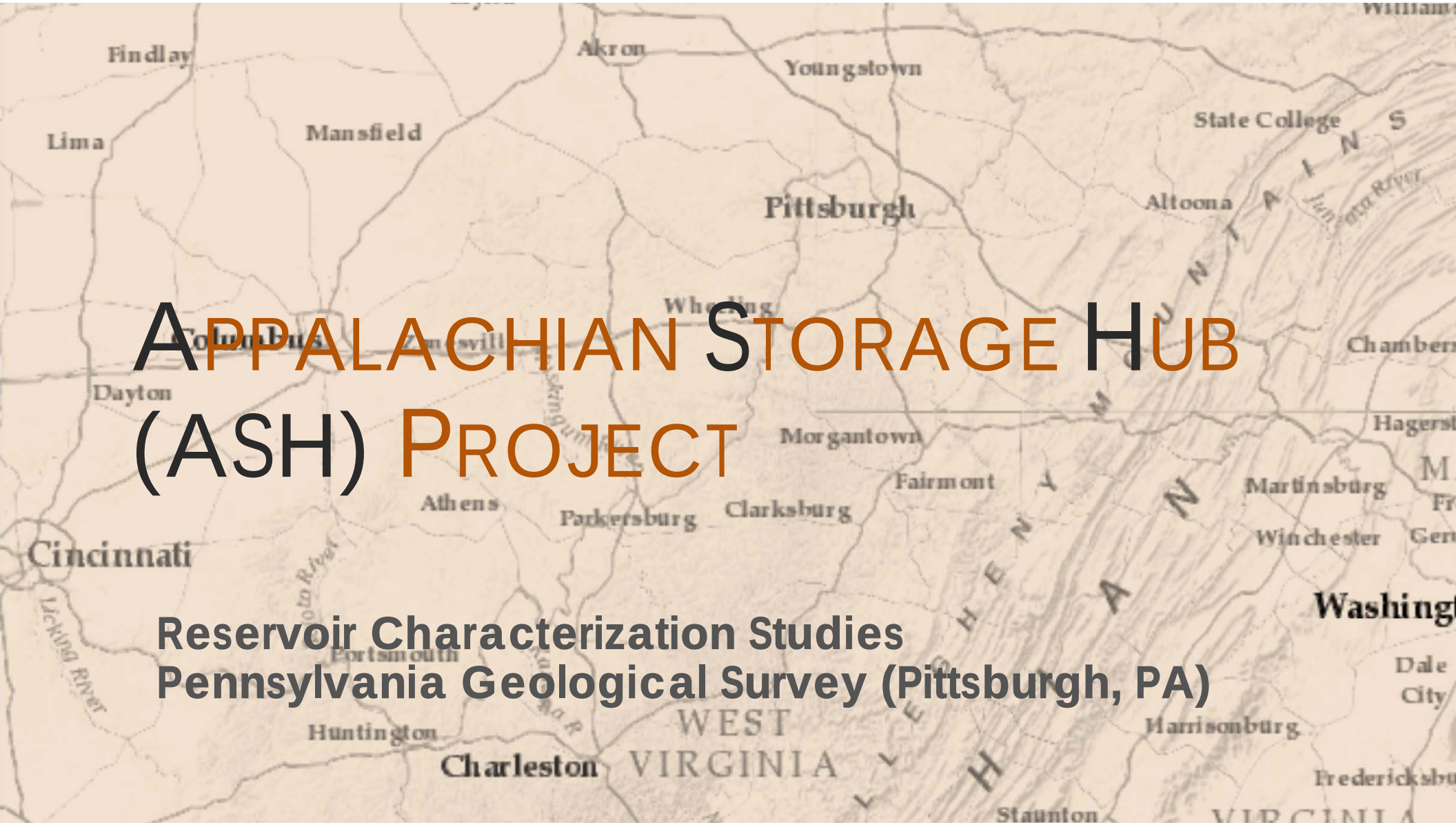


APPALACHIAN STORAGE HUB (ASH) PROJECT

Reservoir Characterization Studies
Pennsylvania Geological Survey (Pittsburgh, PA)

A GEOLOGIC STUDY OF THE POTENTIAL TO BUILD AN APPALACHIAN STORAGE HUB

1. Data collection and project database development
2. Stratigraphic correlation of key units
3. Mapping thickness and structure of key units
4. Studies of reservoir character
5. Develop ranking criteria
6. Recommendations
7. Project Management and Technology Transfer

GEOLOGIC INTERVALS OF INTEREST

Mined-rock caverns

- Greenbrier Limestone (>40 ft thick at depths in excess of 1,800 ft; suitable for mining)

Salt caverns

- Salina Group salts (>100-ft thick preferred; suitable for solution mining)

Gas reservoirs

- Keener sandstone to Berea Sandstone
- Upper Devonian sandstones
- Oriskany Sandstone
- Clinton-Medina Group through Tuscarora Sandstone
- Rose Run and Upper Sandy Member of the Gatesburg Formation

WHAT IS A RESERVOIR, AND WHY DO WE NEED TO CHARACTERIZE IT?

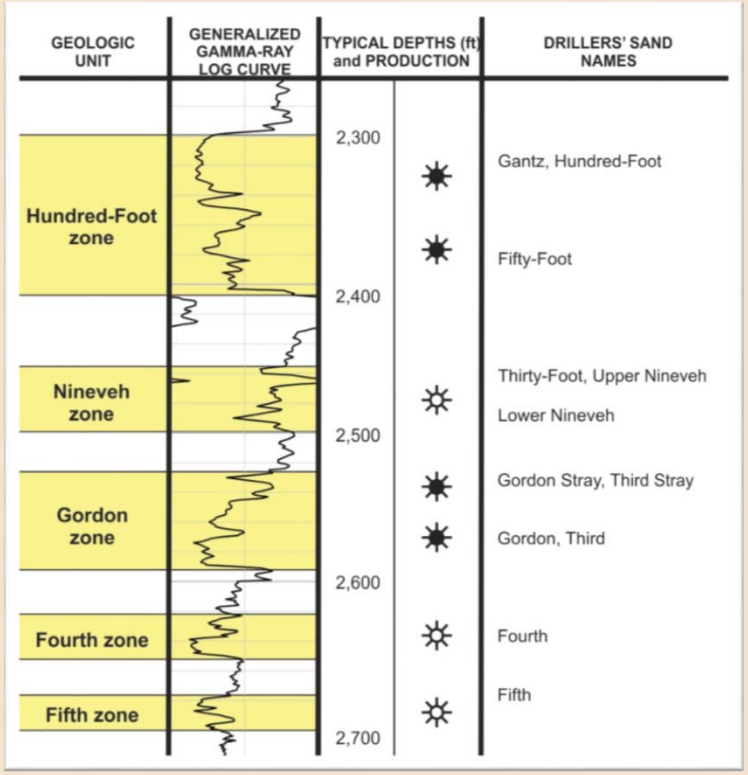
- RESERVOIR – a subsurface volume of porous and permeable rock in which oil or gas has accumulated; a subsurface rock that is saturated with water
- RESERVOIR CHARACTERIZATION consists of many steps, from data gathering and basic interpretation to data analysis and 3-D models of geologic stratigraphy, structure, petrophysics and fluid flow
- Examples:
  - Lithology, depth, thickness and extent of geologic units
  - Contact with seals
  - Porosity, permeability, pressure

EXISTING PUBLISHED RESOURCES

- The Atlas of Major Appalachian Gas Plays (1996)
- Midwest Regional Carbon Sequestration Partnership Geologic Characterization Reports (2005, 2009, 2012)
- Geologic Carbon Sequestration Opportunities in Pennsylvania (2009)
- A Geologic Playbook of Trenton-Black River Exploration (2006)
- Appalachian Basin Tight Gas Reservoirs Project (2008)
- A Geologic Playbook for Utica Shale Appalachian Basin Exploration (2015)
- Subsurface Brine Disposal Framework in the Northern Appalachian Basin (2015)

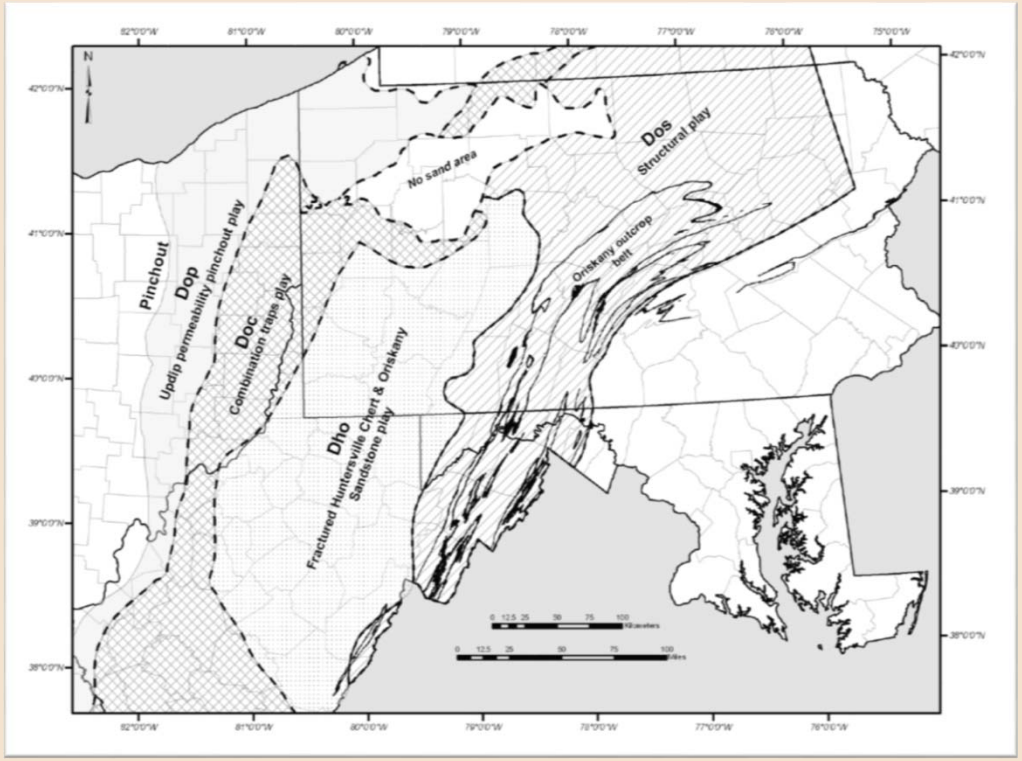
UPPER DEVONIAN SANDSTONES

- Shallow sandstones (~2,000 – 3,000 ft deep)
- Drilled by conventional operators in the Area of Interest (AOI) for more than 100 years
- Multiple (stacked) gas and oil-producing zones
- Individual intervals are limited in extent



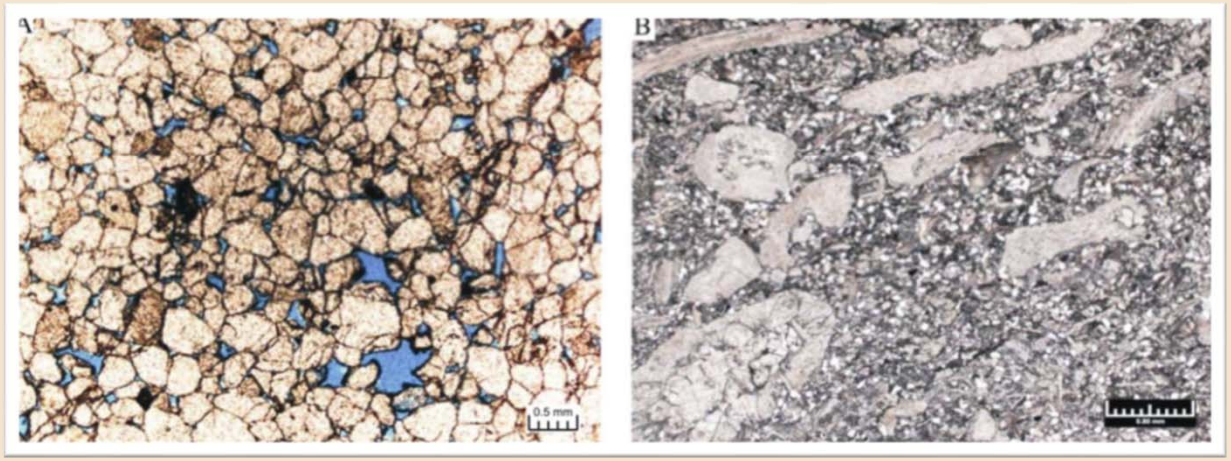
ORISKANY SANDSTONE GAS PLAYS

- Regionally extensive sandstone that correlates across the basin
- Well known by operators and has been researched by many workers
- Produces gas in different areas of the basin through different mechanisms
- DOP, DOC and DHO Oriskany plays are relevant to our area of interest



DOP – UPDIP PERMEABILITY PINCHOUT PLAY

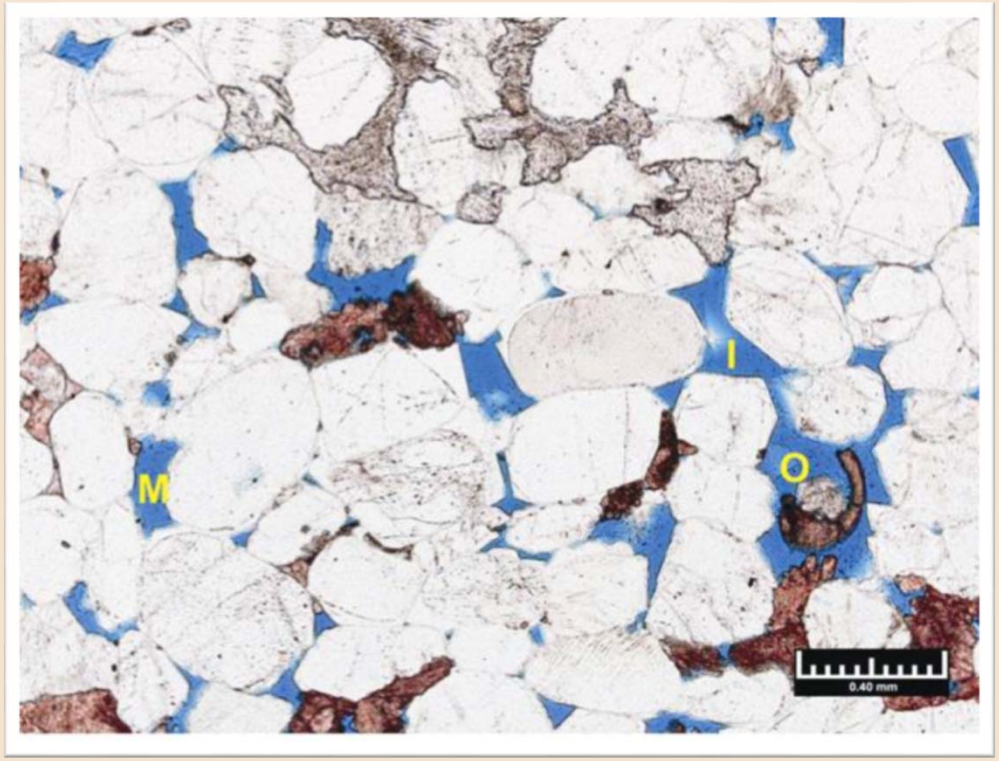
- Left – A typical quartz arenite
- Right – A sandy limestone



- Both are considered “Oriskany Sandstone” but each have their own mineralogy and porosity characteristics
- Moving westward (updip), connectivity of the reservoir (permeability) decreases

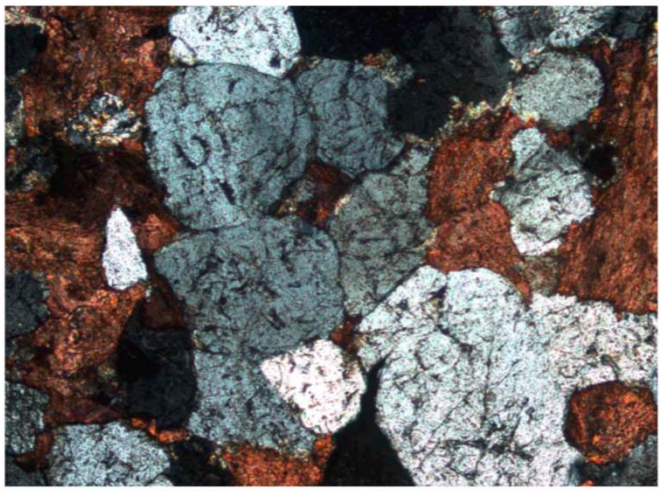
DOC – COMBINATION STRUCTURAL/STRATIGRAPHIC TRAPS PLAY

- Some of the porosity in this combination play is due to structural controls, other to stratigraphic controls
- Primary intergranular and secondary dissolution porosity is visible here – intergranular porosity
- Porosity textures include moldic (M), oversized (O), and enlarged intergranular (I).

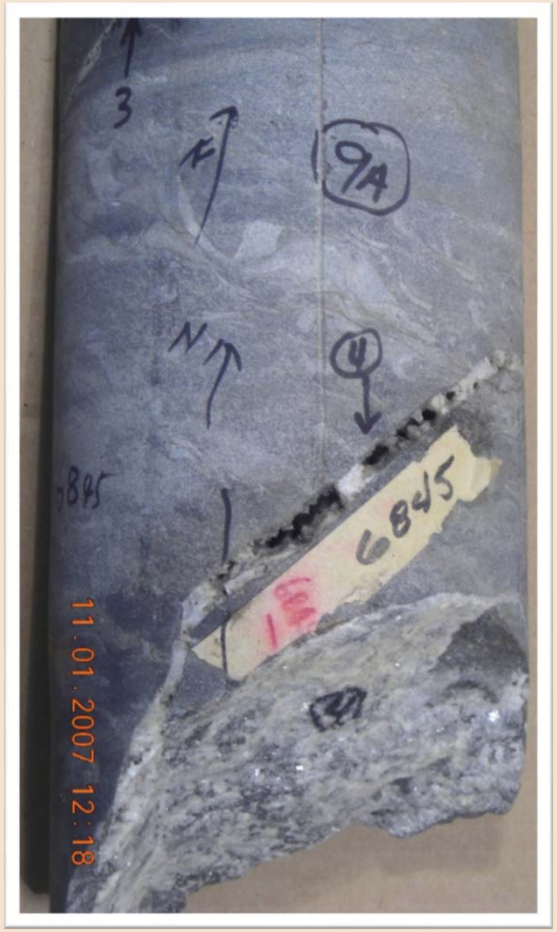


DHO – FRACTURED HUNTERSVILLE CHERT AND ORISKANY SANDSTONE PLAY

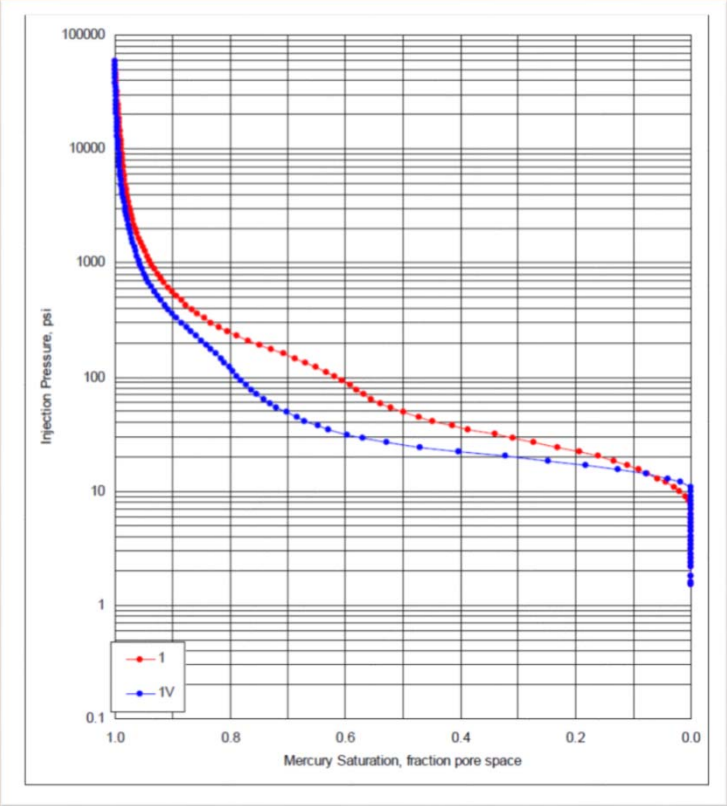
- In this play, the Oriskany Sandstone and overlying Huntersville Chert are hydraulically connected through fractures.
- Right – fracture fill in core sample; fractures have been largely filled with calcite, quartz and pyrite



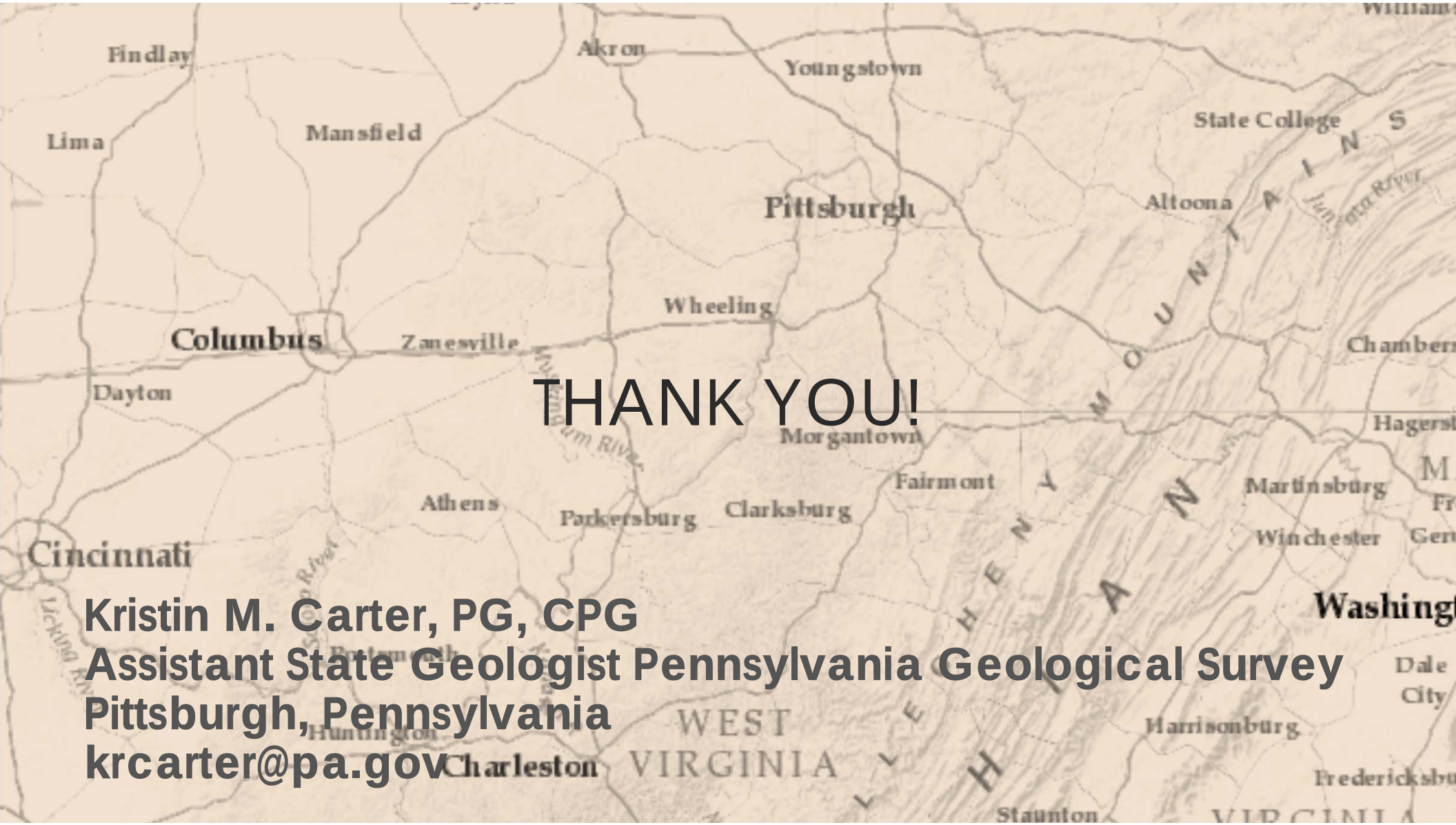
- Left – thin section photomicrograph of medium-grained quartz arenite cemented by quartz overgrowths and calcite



OTHER EXAMPLES OF RESERVOIR DATA



Oriskany Porosity Data[1]		
County	**Field Name**	**Average Core Porosity (%)**
Tucker	Canaan Valley	7
Kanawha	Elk-Poca	8
Jackson	Elk-Poca	8
Jackson	Rockport	17
Putnam	Elk-Poca	8
Randolph	Randolph/ Tucker	9
Tucker	Randolph/ Tucker	9
Wood	Rockport	17



THANK YOU!

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