

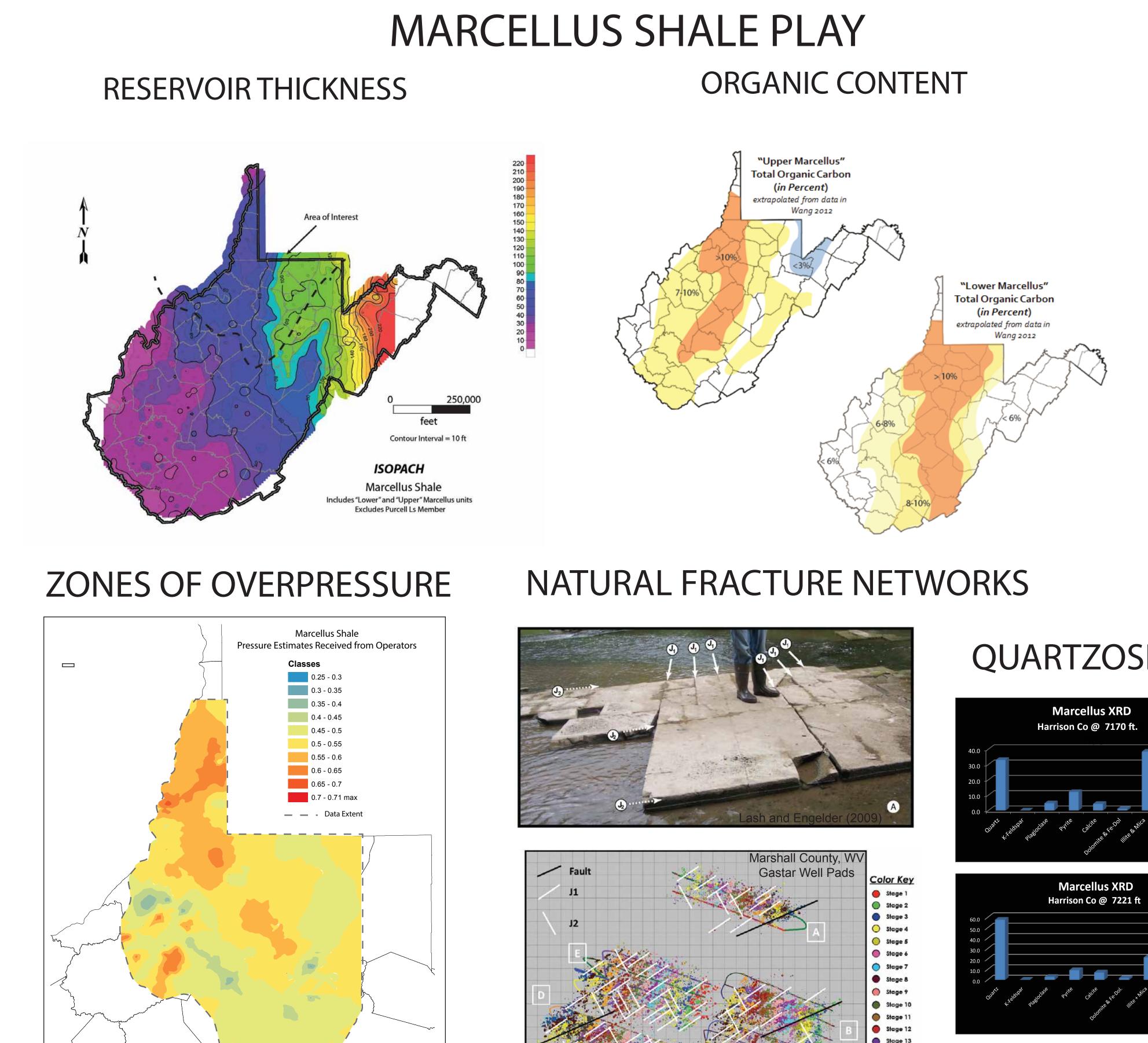
ABSTRACT

Three shale-gas units underlying northern and north-central West Virginia create opportunity for one horizontal well pad to produce from multiple zones. The Upper Ordovician Utica/Point Pleasant, Middle Devonian Marcellus, and Upper Devonian Burket/Geneseo shales yield significant quantities of hydrocarbons in this area, and comparison of individual reservoir characteristics enables construction of fairway maps for each play.

Current drilling activity focuses on the Marcellus, with more than 1,000 horizontal completions reported through mid-2015. Across northern West Virginia, the Marcellus is 40 to 60 ft. thick with a depth range between 5,000 and 8,000 ft. Total Organic Carbon (TOC) is generally 10% or greater. Quartz content is relatively high (~60%) and clay content is low (~30%). Reservoir pressure estimates range from 0.3 to 0.7 psi/ft and generally increase to the north. Volumetric assessment of the Marcellus in this area yields preliminary original gas-in-place estimates of 9 to 24 Bcf/mi2.

The Burket /Geneseo interval is approximately 15 to 40 ft thick across the fairway. The underlying Tully Limestone and Mahantango Formation thin significantly to the west; in places, less than 50 feet separate the Burket/Geneseo from the Marcellus, creating potential to simultaneously complete both formations. This interval may be less conducive to fracture stimulation with relatively high clay (~60%) and low quartz content (~20%). TOC content in this section is generally less than 5%. Seventeen wells report a cumulative volume of 13.2 Bcf of gas and nearly 7,000 bbl of liquids through 2014.

Finally, two recent deep tests of the Utica/Point Pleasant interval in this area each yielded a highly promising 1.0 Bcf of gas in the first three months of production. Reservoir depths range from 10,000 to 12,000 ft and estimates suggest the area is highly over-pressured, with gradients from 0.5 to 0.9 psi/ft. TOC content generally ranges from 1 to 4% and organic-rich shale beds are often thinly interbedded with more carbonate-rich strata. Clay content is typically around 50% in the Utica/Point Pleasant interval; carbonate constitutes 20 to 30% and quartz content is 10 to 20%.



GENESEO/BURKET SHALE PLAY

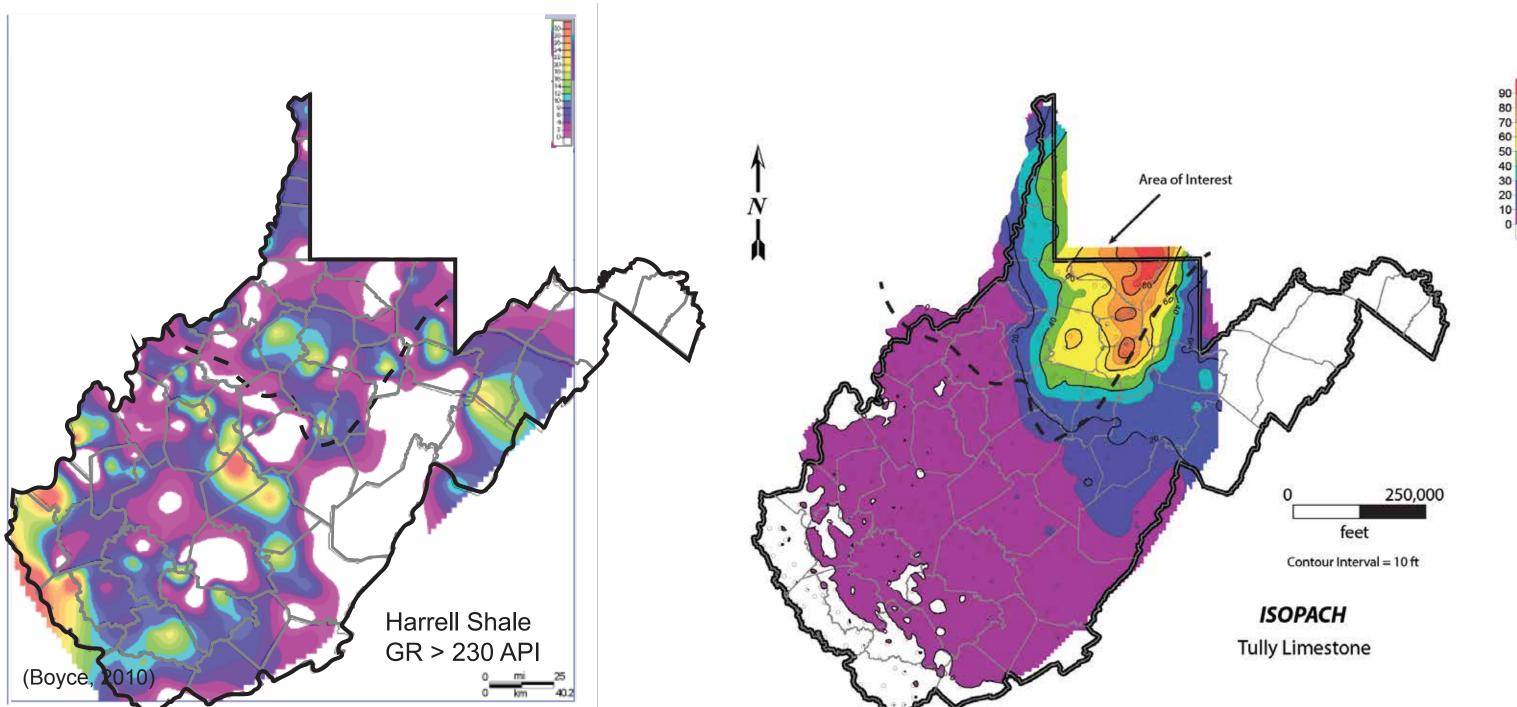
Contour Interval = 10 Geneseo Shale Member of the Genesee Shale (S and W)

RESERVOIR THICKNESS

ORGANIC CONTENT

ure 7: Microseismic events for Marcellus case study. Events are colored by stage and sized by energy. Fault, J1, and J2 features are visible in the data and illustrated by lines with respective color and orientation.

Neuhaus et al., 2012 (SPE 16195)

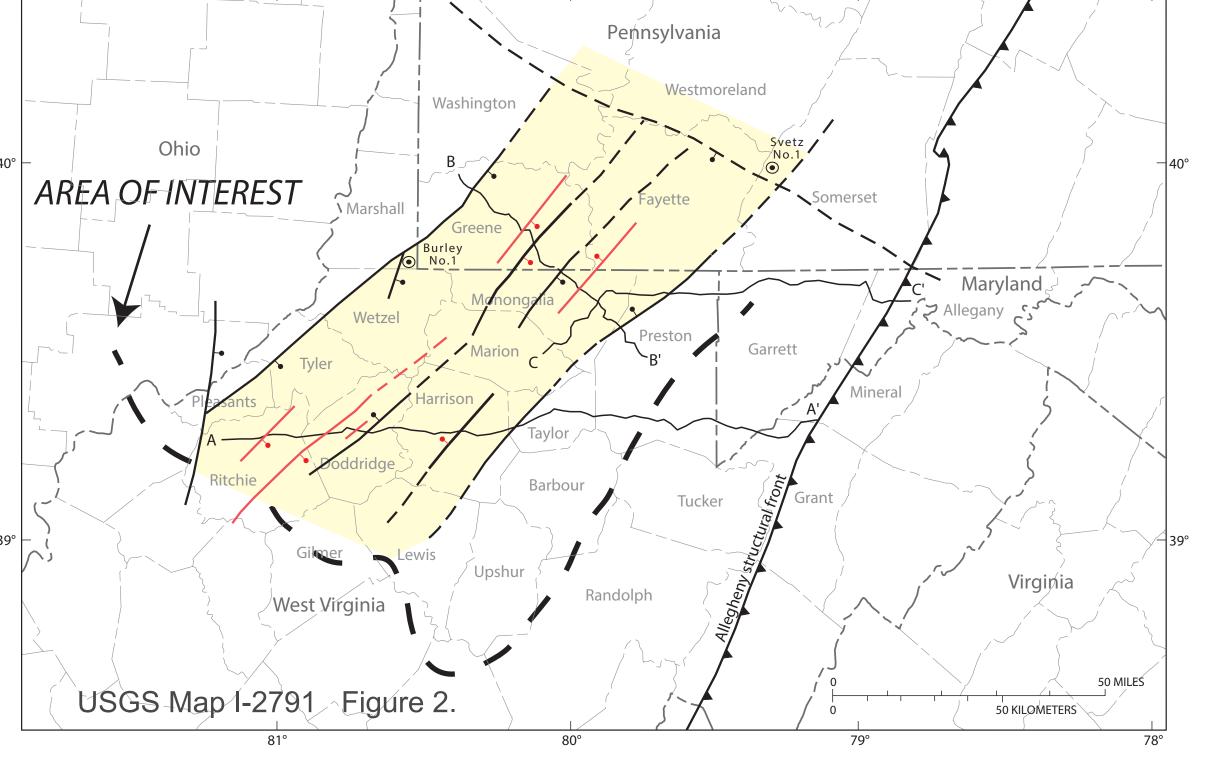


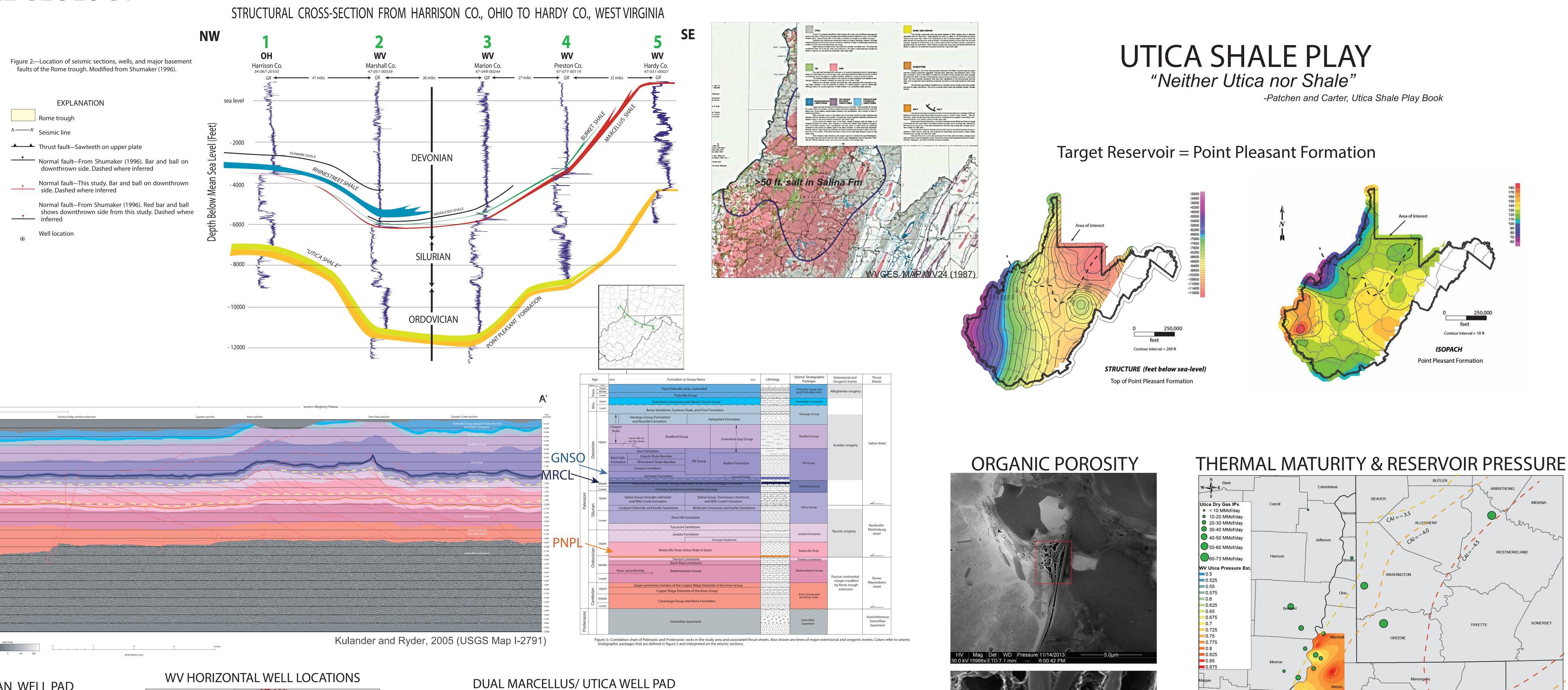
EVALUATION OF POTENTIAL STACKED SHALE-GAS RESERVOIRS ACROSS NORTHERN AND NORTH-CENTRAL WEST VIRGINIA

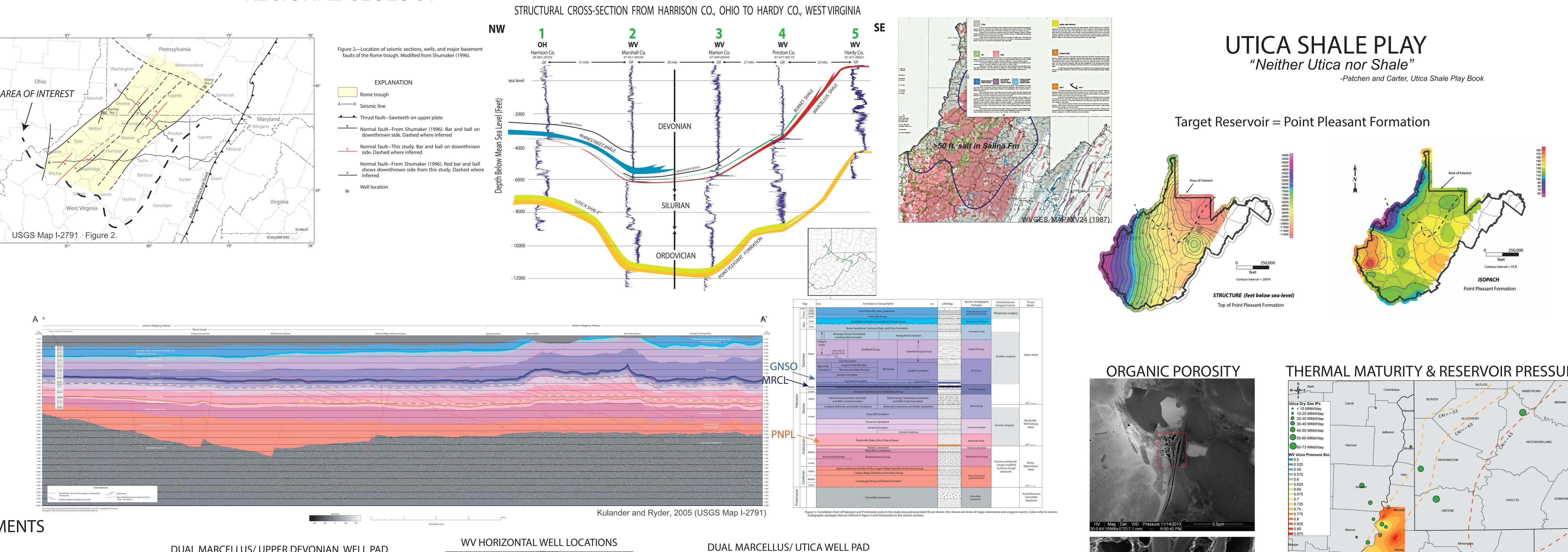
Jessica Pierson Moore¹, Susan E. Pool¹, Philip A. Dinterman¹, J. Eric Lewis¹, Ray Boswell²

¹West Virginia Geological & Economic Survey, ² U.S. DOE National Energy Technology Laboratory

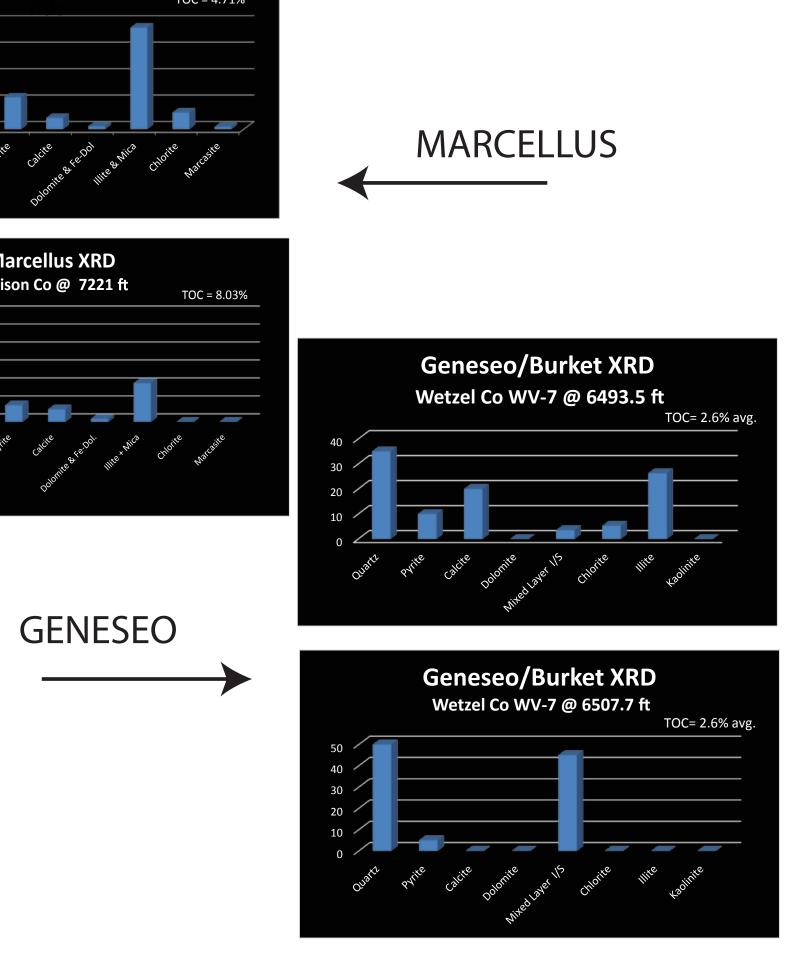
REGIONAL GEOLOGY



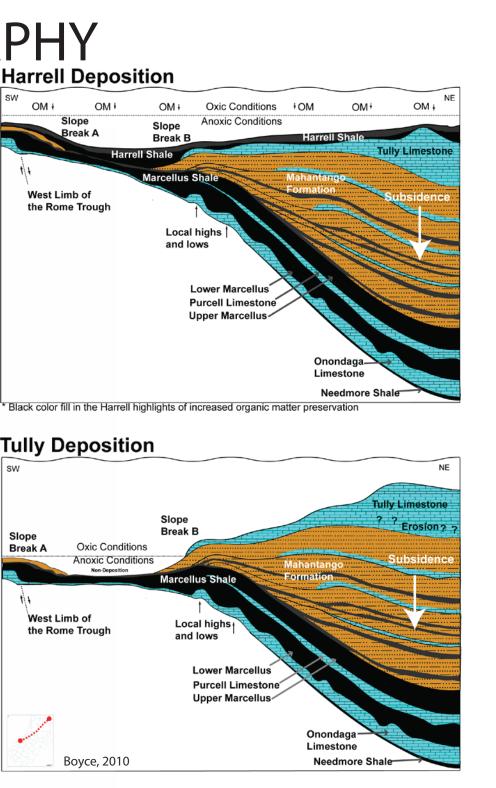




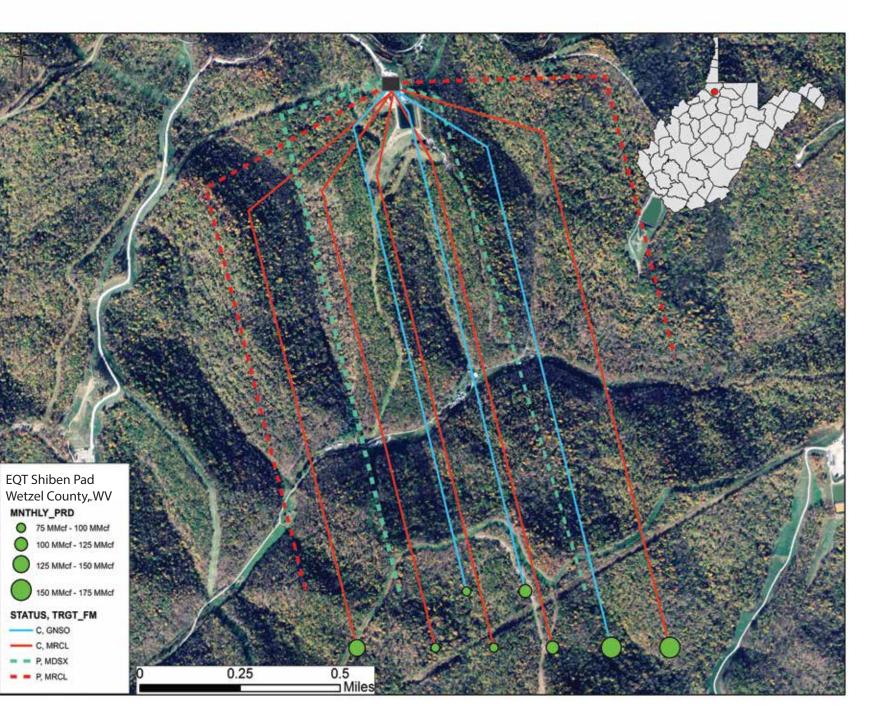
QUARTZOSE SEDIMENTS

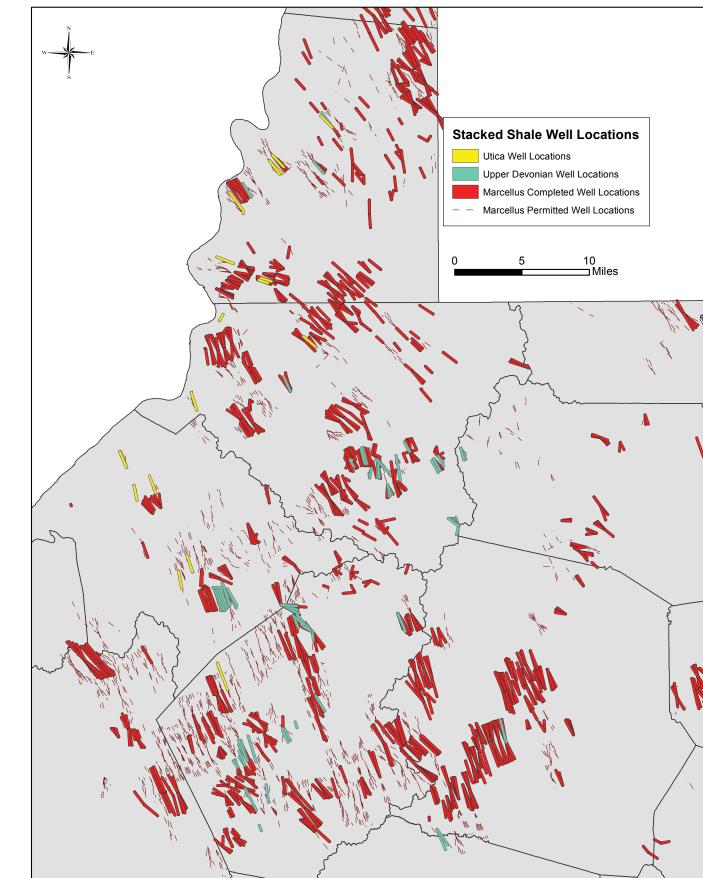


ANTECEDENT TOPOGRAPHY



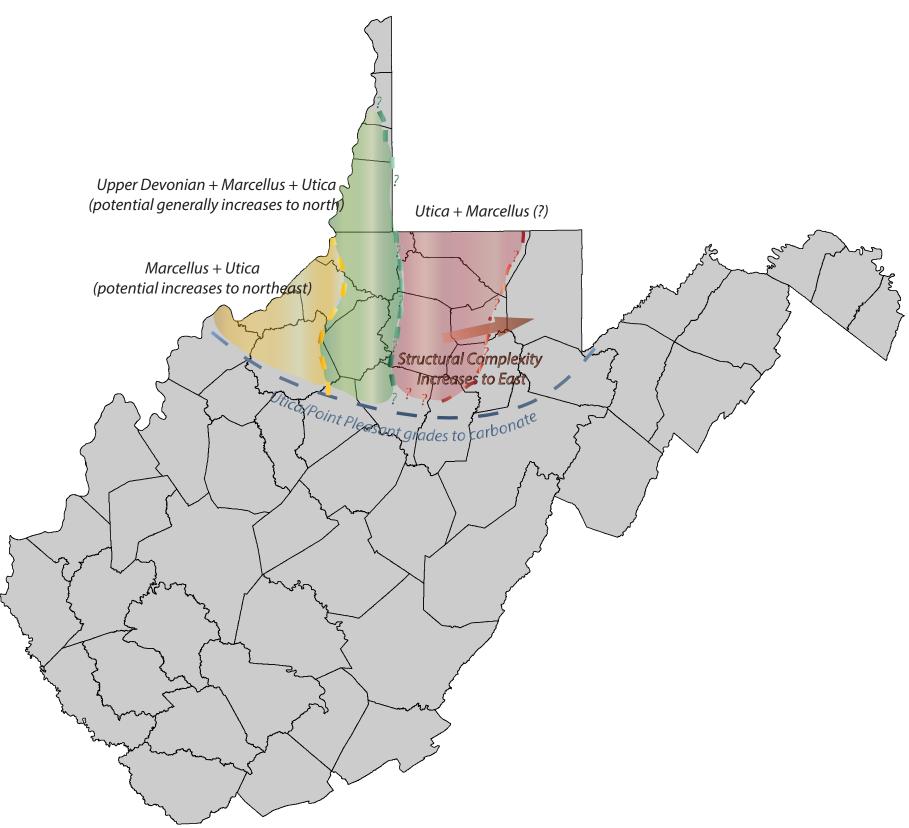
DUAL MARCELLUS/ UPPER DEVONIAN WELL PAD WETZEL COUNTY, WV



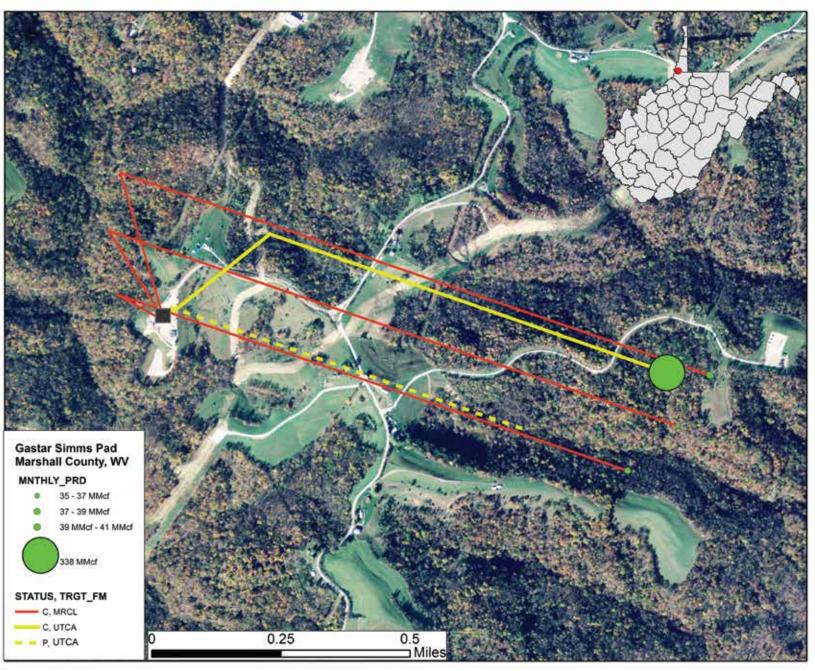


Geneseo and Marcellus completed wells exhibit similar average monthly production; pad also has two wells permitted to the Middlesex

GENERALIZED FAIRWAY MAP



MARSHALL COUNTY, WV



Three Marcellus wells were completed in 2011; these wells have an average cumulative gas production of 1.3 Bcf. The Utica well, completed in 2014, has produced 1.6 Bcf in a span of only five months

RESOURCE POTENTIAL AND IMPLICATIONS FOR DEVELOPMENT

Presence of multiple unconventional shale gas units in northern West Virginia presents a unique and challenging opportunity for development of the resource. Pool (2013) estimated that the Marcellus Shale contains 122 Tcf of original gas-in-place; this number is likely conservative due to a lack of accurate reservoir pressure estimates at time of publication. An updated volumetric assessment of Devonian shale units in WV is currently underway. Basin-wide assessment of the Point Pleasant Formation (Hohn et al., 2015) yields OGIP estimates of approximately 1,745 Tcf. Northern West Virginia is situated favorably within the "sweet spot" of the reservoir; acreage in West Virginia accounts for 10-15% of the overall area.

Development of the Point Pleasant is anticipated to move eastward following successful test wells in the eastern portion of the Pennsylvania fairway. This development will occur within the footprint of Marcellus drilling, which presents challenges for acquiring contiguous deep mineral rights as well as siting well pads in steep topography.

A final consideration for development of stacked shale units in West Virginia is pressure regime--maintaining it in the Devonian section, and controlling it in the Point Pleasant. Completion techniques will likely be modified using lessons learned from early development, as necessity is so often the mother of invention.

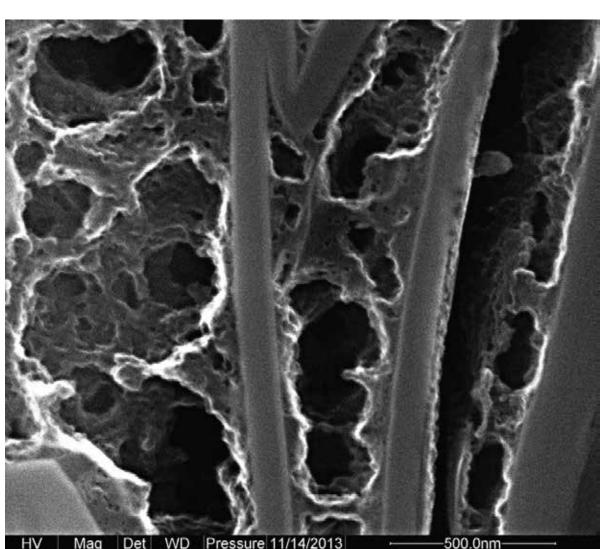












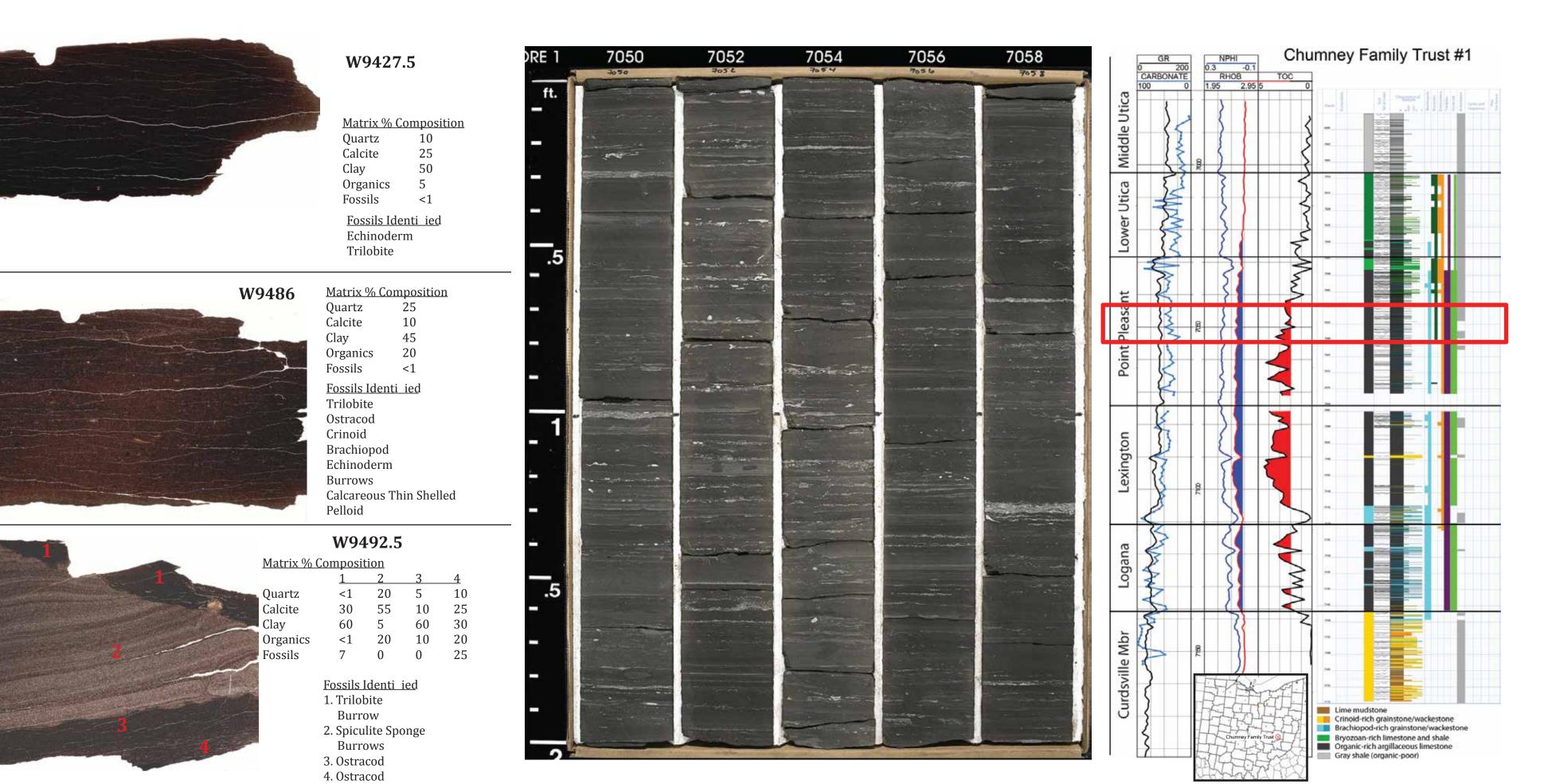
Point Pleasant XRD Marion-244 @ 12,940 ft

Point Pleasant XRD

Marion-244 @ 13,045 ft

SEM Image of well-developed organic porosity in the Point Pleasant Formation (core 74NY5). Thermal maturity of the samples is above 3.0% Ro. The Point Pleasant Formation notably lacks intergranular porosity; a majority of pores are located within organic material. As the reservoir matures, the pore networks become more robust and interconnected. From Carter and Soeder, 2015. Images and analyses courtesy of Juergen Schieber (Indiana University).

INTERBEDDED CARBONATE AND ORGANIC SHALE



WOOD-351 THIN SECTION ANALYSIS (R. McDowell and D. Skerbitz, WVGES)

CHUMNEY FAMILY TRUST CORE ANALYSIS (T. Smith, Smith Stratigraphic, LLC)