Refined Lithostratigraphy of Upper and Middle Devonian Shales in West Virginia*

Ray Boswell¹ and Susan Pool²

Search and Discovery Article #30607 (2019)**
Posted June 10, 2019

Abstract

The evolution of the formal lithostratigraphy for the Middle and Upper Devonian strata in the central Appalachian Basin has been complex. The original terminology (Chemung, Portage, Marcellus, Catskill, and others) was assigned late in the 19th century. However, by the 1930s, the realization that these units changed in nature dramatically when traced laterally resulted in a crisis in stratigraphy that forced the differentiation of chronostratigraphy from lithostratigraphy. Further, the sheer size of the basin creates challenges, as stratigraphic terminology defined by examination along the outcrop belts at the basin margins is difficult to extend into the subsurface due to the distances involved, the different nature of outcrop and subsurface data, the different perspective of workers attempting to extend units either from the north and west or from the east, and the complex facies changes within the strata. As a result, the facies architecture and associated lithostratigraphic nomenclature for many Middle and Upper Devonian units remained unsettled, particularly in the basin center.

This study (see Boswell and Pool, 2018) uses log data from nearly 400 wells from West Virginia to produce detailed maps of the economically important, organic-rich facies and identifies various associated vertical and lateral lithostratigraphic unit boundaries. The study focuses on the Middle Devonian Hamilton Group and its constituent Marcellus and Mahantango formations. Within the Marcellus, a lower Union Springs Member, a middle Cherry Valley Member, and an upper Oatka Creek Member are defined within northeastern West Virginia only. Throughout the rest of the subsurface of the State, the Marcellus has no distinguishable members. In the Upper Devonian, the occurrence and limits of the Harrell Shale (and its basal Burket
Shale Member), and its westward lateral transition into the largely-correlative Genesee Formation (with basal Genesee Shale and upper West River Shale members) are mapped. Maps also detail the position at which the Sonyea Formation (with basal Middlesex Shale and upper Cashaqua Shale members), West Falls Formation (with basal Rhinestreet Shale and upper Angola Shale members), Java Formation (undifferentiated), and lower part of the Huron Member of the Ohio Shale transition eastward into age-equivalent strata of the Brallier Formation.

Selected References


Williams, H., 1900, Catskill Formation sedimentation: Geological Society of America, Bulletin v. 11, p. 594-595.


Refined Lithostratigraphy of Upper and Middle Devonian Shales in West Virginia

Eastern Section AAPG, October 9, 2018

Ray Boswell (DOE-NETL) and Susan Pool (WVGES)
Stratigraphy

In the beginning...

• No differentiation was made between litho-, bio-, and chrono- stratigraphy
  • Rocks do not change laterally!

• 1820s: Amos Eaton
  • Observes apparent lateral lithologic and age changes in the Catskill Fm. This observation is not appreciated.

• 1830s: NY and PA successions developed
  • J. Hall, H. Rodgers: Onondaga-Marcellus-Hamilton-Tully-Genesee-Portage-Chemung-Catskill-Pocono

• 1900s: Eaton’s observation resurfaces
  • G. Chadwick, H. Williams… A crisis of stratigraphy
Kenneth Caster, 1934

Lithofacies boundaries cross timelines on a regional scale

Fig. 2.—Facies components
1940s - 1990

EGSP, etc...

Old terminology slowly replaced
• Portage → Brallier (Woodward, 1943)
• Catskill → Hampshire (Butts, 1945)
• Chemung → Greenland Gap (Dennison, 1970)

U Devonian Shale section
• “undiff. Devonian”, “brown shales”

Eastern Gas Shales Program
• Schwietering, de Witt et al. track NY stratigraphy south and east into basin center.
• System emerges of Fms with paired members; organic-rich at base.
• Reconciliation with established age-equivalent, shoreline-proximal strata not clear.
West Virginia Shale Lithostratigraphy

Well established, widely-used...

Ohio
- Cleveland Sh M
  - Three Lick Bed
  - upper part
  - middle part
  - lower part
- upper part Huron Member
- lower part Huron Member

Java
- Hanover Sh M
- Pipe Creek Sh M

West Falls
- Angola Sh M
- Rhinestreet Sh M

Sonyea
- Cashaqua Sh M
- Middlesex Sh M

Genesee
- West River Sh M
- Genesee Sh M
- Tully LS

Hamilton Group
- Mahantango Fm
- Marcellus Fm

This Study
Data and Methods

~400 vertical wells; GR-DEN; relative base line method
Document lithostratigraphy

- As revealed by subsurface data
- Avoid new names
- Precedence
- Utility
- Lithologic consistency

Recognize the 3-D problem

- Formations need not only top and bottom, but edges
- Clarify lateral transitions, particularly where lithologic units “fade away”
Gradational Lateral Transition

What about a well drilled in this zone?
Methods

Lateral lithofacies boundaries

- To the east, the organic-rich units do not pinch out, they fade away.

- The age-correlative interval can still be readily correlated; but that does not mean it is the same lithologic unit!

- Lateral boundary placement fairly arbitrary—if tracing from the west, one would tend to extend the shales further.

- Goal was to place the line near the 50:50 point (non-quantitatively).

- This may look very arbitrary for locations near this line.
GOAL: Retain the structure of organic-rich shale/organic-poor shale couplets comprising two members of a Formation.

Those formations are tracked until 1) they change facies (organic-rich) or 2) they lose defining upper or lower boundary (organic poor).

Upper boundary extent generally controls this.

Where organic-rich member persists beyond point where overlying member is not mappable, it becomes a Formation (per Harper et al., 2017).
Example

West Falls Formation

• Angola Member (upper) lateral facies transition (blue line).

• That boundary (and eastward limit of the Java Fm above) is determined based on the western extent of the next organic-rich shale up (Huron).
Example

West Falls Formation

- Correlative interval has graded into age-equivalent organic-poor shales of the Brallier Fm (east of blue line).

- Rhinestreet Shale Member of West Falls Fm (west of red line).

- Rhinestreet Shale (Fm status: between red and blue lines).
Middlesex Shale

- Middlesex Shale Mbr of Sonyea Fm (west of red line).

- Middlesex Shale (between red and blue lines).

- Correlative interval has graded into Brallier Fm organic-poor shale (east of blue line).
• Geneseo Shale Mbr of Genesee Fm (west of blue line).

• Burket Shale Mbr of the Harrell Shale (east of blue line).
Results

Middle and Upper Devonian organic-rich shale lithostratigraphy in West Virginia

Younger shales

• Pipe Creek not readily mappable (informal unit): Java Fm without members

Mahantango Formation

• Complex to recognize alternative units (Skaneateles, Ludlowville, etc.) as in NY and PA.
• Separating limestones are very thin and lose definition into WV to the south.

Marcellus Formation

• PA members only mappable to point medial limestone member is mapped (LINE C).
• To west, informal sub-units can be mapped but are lithologically very similar (in log data).
Results

Marcellus lithostratigraphy

- Mbrs only where Cherry Valley can be confidently mapped.

- Informal units to the west, delineated by informal and thin “Purcell” and “Cherry Valley” lime-rich driller’s units (per de Witt et al., 1993 and some industry practice).

- Unnamed unit at the base: “transition zone”.

- Top of Marcellus is progressively younger to the west.
Cherry Valley Mbr

• Exists as a formal member in eastern WV (between blue and red lines).

• Correlates to several low GR/high DEN spikes to the west which generally mark the transition between informal “lower” and “upper” Marcellus (west of blue line).

• Correlates to the Purcell Mbr in the eastern panhandle (east of red line: similar to Harper et al., 2017).
Ongoing resource assessment revealed unsettled formal nomenclature for many Upper and Middle Devonian shale units.

Well-established stratigraphy exist on the east and on the west, but uncertain how to merge them in the basin center.

Issues particularly with respect to the Marcellus and the Geneseo/Burket units.

3-part release planned:
- Part 1: Base data and lithostratigraphy (WVGES RI-35)
- Part 2: Updated GIP for multiple units (TBD)
- Part 3: Assessment of recoverable resources and recovery efficiency (TBD)

WVGES RI-35 contains multiple products…

Thanks to our reviewers: B.J. Carney (NNE); K. Carter & J. Harper (PGS); T. Carr & D. Patchen (WVU); M. Trippi (USGS); A. Douds (Parsley); M. Blake & M. Hohn (WVGES)
Lithostratigraphy of Middle and Upper Devonian Organic-Rich Shales in West Virginia - Reports of Investigation RI-36

Gamma-ray log stratigraphic cross-sections
Zoom in online to see details; cross-sections designed to fit on 11 x 17 inch (tabloid) paper in landscape mode.

West to East
- West to East 1
  - Marshall, Wetzel, Minford, and Meigs Counties

- West to East 2
  - Pleasants, Ritchie, and Wood Counties

- West to East 3
  - Wood, Wirt, Ritchie, and Wayne Counties

- West to East 4
  - Mason, Jackson, Roane, and Putnam Counties

- West to East 5
  - Mason, Putnam, Kanawha, and Cabell Counties

- West to East 6
  - Cabell, Lincoln, Brooke, and Marion Counties

North to South
- North to South 1
  - Hancock, Ohio, Marshall, Wetzel, Tyler, Pleasants, Wood, Ritchie, Wirt, Jackson, Mason, Putnam, Cabell, and Wayne Counties

- North to South 2
  - Greene (PA), Monongalia, Marion, Hampshire, Lewis, Gilmer, Calhoun, Roane, Kanawha, Boone, Logan, and Mingo Counties

- North to South 3
  - Preston, Barbour, Upshur, Webster, Nicholas, Fayette, Raleigh, Wyoming, Mingo, and McDowell Counties

- North to South 4
  - Mineral, Grant, Pendleton, Randolph, Webster, Greenbrier, Summers, and Mercer Counties

Page last revised May 11, 2010.
# West Virginia Geological & Economic Survey (WVGES): Middle and Upper Devonian Organic-Rich Shale Lithostratigraphy, Study Wells

## WELL DATA

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## TOPS (log-measured depth, ft)

- **Upper Portion of Outcrop**: Member Wise & Member Upper
- **Lower Portion of Outcrop**: Member Upper & Member Lower

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**Note**: The table above includes data on API numbers, county codes, county names, parity numbers, surface locations, years, elevations, temperatures, and formations for wells in the study area. The TOPS section provides information on the upper and lower portions of outcrop for specific member groups.
Interactive Mapping Application

Middle and Upper Devonian Shales

http://www.wvgs.wvnet.edu/gis/og/MUDvnnSh/index.html
Thank You