The Origin and Significance of the Lower Mississippian Sunbury Shale in East-Central United States*

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Abstract

The Sunbury Shale is a relatively thin, Lower Mississippian, organic-rich, black-shale unit that is prominent throughout eastern Ohio, eastern Kentucky and western West Virginia. The Sunbury is the most widespread of the Devonian-Mississippian black shales. Where it occurs in the western Appalachian Basin, it is commonly separated from the black, Upper Devonian Ohio Shale by the gray shales, silts and sandstones of the Bedford-Berea sequence. However, in parts of eastern and central Kentucky, where the Bedford becomes a black shale, the Sunbury merges with black Bedford and Ohio shale equivalents to become the uppermost part of the New Albany and Chattanooga shales. The unit even crosses the Cincinnati Arch into the Illinois Basin and is present in the Michigan Basin, where it attains thicknesses greater than 45 m. To the northeast in northern West Virginia and western Pennsylvania, the Sunbury grades into the much thicker (> 70 m) and more clastic-rich Riddlesburg Shale, which reflects a marginal-marine embayment.

The black-shales of the Devonian-Mississippian sequence all represent subsidence and early deep-water infilling of foreland basins associated with orogeny in the east. Early to Late Devonian black shales all represent deformational loading and foreland-basin infilling associated with the Acadian Orogeny, and these shales occur in basins that migrate southwesterly in time and space. The Sunbury-Riddlesburg, however, is different in that it migrated eastward in time and space, and recent work shows that it represents foreland-basin subsidence accompanying inception of the Early Mississippian Neoacadian Orogeny in New England. The Neoacadian Orogeny represents the initial collision of the exotic Carolina terrane at New England and the terrane’s subsequent southwestward transpressional convergence with the eastern margin of Laurussia (North America). In
response, the initial Sunbury-Riddlesburg Basin formed just cratonward of the orogen in western Pennsylvania and northern West Virginia and subsequently expanded southwestwardly along with dextral transpression in the orogen. While the Sunbury and its equivalents represent a deeper, sediment-starved, foreland-basin infilling, the overlying Price-Pocono-Borden-Grainger clastic units represent relaxational, post-orogenic, deltaic complexes that developed from erosion of Neoacadian Mountains formed in the orogen. Economically, it is thought that the Sunbury may have sourced conventional reservoirs in the underlying Bedford-Berea sequence as well as in the overlying Lower Mississippian clastic units. However, in places throughout the western Appalachian Basin where it has sufficient thickness and TOC greater than 20%, the unit should probably be examined as a future unconventional resource.
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Talk Outline

I. Characterization
II. Riddlesburg equivalent
III. The Neoacadian Orogeny and the Sunbury Shale
IV. Summary
I. Characterization

Sunbury Shale (Su)

Black-shale package

Appalachian Basin Cross Section

Ettensohn et al., 2019
Characteristics Gamma-Ray Signature

Morehead, KY (Rowan Co.)

Legend:
- Limestone
- Sandstone
- Shale, mudstone
- Dark shale

Vertical Scale:
- ft (meters)
- 30 ft (10 m)

Underlying Unconformity
In the New Albany and Chattanooga Shales in east-central Kentucky, the Sunbury merges with underlying black shales where the Bedford equivalent becomes black.
Sunbury equivalent in the New Albany Shale at Louisville, KY, in Jefferson Co. (J)
Distribution and Thickness of the Sunbury and its Equivalents in the East-Central U.S.
II. Riddlesburg Equivalent

Riddlesburg Mbr. equivalent of the Sunbury Shale at Sideling Hill, MD
Correlations between the Sunbury and Riddlesburg Mbr. at Sideling Hill, MD
Uppermost part, New Albany Sh.  
Sunbury Shale  
Riddlesburg

Thickest Sunbury, SW Virginia
III. The Neoacadian Orogeny and the Sunbury Shale

Sunbury is part of the Devonian-Mississippian black-shale sequence.

The black shales represent early flexural subsidence in response to deformational loading in the Acadian and Neoacadian orogenies.

The black-shale basins migrate in space and time as they track the progress of orogeny.

**Time 1**

a.) Subsurface or subaqueous loading

b.) Rapid subsidence, underfilled, sediment-starved basin

c.) No major clastic sources

d.) Organic matter from water column and suspended clays and silts are major sediments

e.) O2-deficient conditions preserve organic matter

**Time 2**

a.) Surficial load developed

b. Drainage nets developed

c.) Coarse-grained clastic influx into basin
Acadian/Neoacadian (Devonian-Mississippian) stratigraphic sequence in the Appalachian foreland basin.
Acadian/Neoacadian Tectonic Framework

Pre-Acadian

Early Acadian

Late Acadian

Neoacadian

Sinistral transpression

Head-On convergence

Scissors-like convergence

Collision & transpressional convergence (dextral)
Earliest Mississippian - Sunbury Time

Paleogeography, Tectonics and the Distribution of the Sunbury-Riddlesburg Shales

Initiation of the Neoacadian Orogeny
IV. Summary

- Sunbury black shales represent deeper-water, foreland-basin deposition during the Early Mississippian Neoacadian Orogeny.

- The shales are up to 90-ft thick in a north-south belt through eastern Ohio, western West Virginia and southwestern Virginia, which approximates the most actively subsiding parts of the Neoacadian foreland basin.

- Sunbury equivalents to the south and west are extremely thin and condensed, representing starved-basin sedimentation beyond the foreland-basin sink.

- To the northeast, the Sunbury grades into the clastic-rich and marginal-marine Riddlesburg Shale, which filled a subsiding embayment behind the new York promontory, the initial locus of Neoacadian convergence.

- The Sunbury Shale and its overlying clastic wedge (Borden-Grainger-Price-Pocono) represent the initial collision of Carolina at the New York Promontory and its subsequent southwestward transpressional collision with the southeastern margin of Laurussia.

- With TOC values up to 20%, the Sunbury might be a viable unconventional resource, but probably only in an area near the junction of Kentucky, West Virginia and Virginia, where thicknesses are sufficient.