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Review

Age and Correlation of the Moorefield Shale (Upper Mississippian) in its Type Area, Northeastern Arkansas

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Running Title: Age and Correlation of the Moorefield Shale (Upper Mississippian), Northeastern Arkansas

Abstract

The name Moorefield was proposed by Adams and Ulrich (1904) for exposures of gray to brown, phosphatic shale with a basal limestone, overlying the Lower Mississippian Boone Formation, and underlying the Upper Mississippian Batesville Sandstone, in the vicinity of Moorefield, Independence County, northeastern Arkansas. Gordon (1944) 1) restricted the name Moorefield to the lower limestone-bearing interval, 2) applied a new name, Ruddell, to the succeeding shale section that comprises the bulk of the interval, with a type area near Moorefield, and 3) interpreted the interval contacts as unconformities. The name Ruddell was used for the revised Geological Map of Arkansas (1993), but later publications by the Arkansas Geological Survey and other sources refer the entire interval to the Moorefield Shale, and report a maximum thickness of 91.44 m. (300 feet).

Age assignments for the Moorefield Shale are based almost entirely on ammonoid cephalopods (*e.g.* Gordon 1965, Saunders et al. 1977, Korn and Titus 2011). Brachiopods (*e.g.* Girty 1911) have provided a supporting role, but never to the precision of the ammonoids. Initially, Gordon (1965) recognized two ammonoid zones and four subzones through all the Moorefield, except the base. Korn and Titus (2011) reexamined Gordon's published ammonoid assemblages, and made additional collections from the type Moorefield. They recognized only two Moorefield ammonoid zones: the lower *Goniatites eganensis - Girtyoceras welleri* zone, succeeded by the upper *Goniatites multiliratus* zone concentrated near the middle of the interval. The best age assignment for these abundant, middle Moorefield ammonoid assemblages is to the lower Chesterian Series (Korn and Titus 2011). The unfossiliferous lower Moorefield Shale spans the Meramecian-Chesterian boundary. The upper section, above the ammonoid occurrences, but also barren of ammonoids, and other biostratigraphically useful fossils, likely extends to at least the middle Chesterian. Thus, the bulk of the Moorefield formation represents the Chesterian, not the Meramecian Series. This age assignment is complicated further by the reduction of the lithostratigraphic units comprising the type Meramecian Series (Lane and Brenckle 2005), and a lack of ammonoid assemblages in its type area, St. Louis County, Missouri.

History of Moorefield Stratigraphic Investigations

The earliest record of systematic geological observations in northern Arkansas was by David Dale Owen, in a volume treating the northern counties published in 1858. Owen was appointed state geologist by Governor E. N. Conway on April 20, 1857. He arrived in Arkansas in early October, 1857, and began working in the northeastern corner, Greene County, proceeding westward across the northern two tiers of counties. The work was done on horseback and supported by horse-drawn wagons, focusing on potential economic mineral deposits. Independence County was the fourth county visited, and Owen's descriptions comprise eight pages of his first 256 page report (Owen 1858). Owen recognized the Archimedes Limestone (=Pitkin Limestone), and what is likely the Batesville Sandstone overlying a 9.14 m. (30 foot) section of brown-black shale with limestone intervals that is probably the Moorefield Shale, but did not name either interval. The northern counties report included at least some description of the geology of 18 counties. It was followed by a second report on the middle and southern counties, published in 1860 that concluded his survey of Arkansas. Owen died on November 13, 1860.

During Reconstruction, the Arkansas legislature appointed a series of state geologists and funded some geological work, but it was not until January 19, 1887 that an Arkansas Geological Survey was organized,

with J. C. Branner as State Geologist, and a staff of young geologists that would become well-known in the profession. Again, the Survey was charged with an assessment of potential economic mineral occurrences, some of which had been identified by Owen (1858, 1860). In particular, the Survey was to evaluate the validity of a gold rush that had developed in the mid-1880s in the Ouachita Mountain region. In fact, the first publication of the new geological survey authored by T. B. Comstock (1888) exposed the Ouachita gold rush as a scam. On a brighter side, the Branner Survey hired the well-known geologist Richard Alexander Fullerton Penrose Jr. to investigate manganese occurrences in northeastern Arkansas, particularly the area surrounding Batesville, Independence County, that proved to be a legitimate resource.

The Penrose report (1891) was the first volume published by the Arkansas Geological Survey for work in 1890. It provided a stratigraphic column (Fig. 1), but from the current perspective, there are several problems. Most significantly, Penrose shows the Fayetteville Shale lying between the Boone Chert and the Batesville Sandstone in Independence County (Fig. 1). In fact, that shale has become known as the Moorefield Shale, while the Fayetteville Shale lies above the Batesville Sandstone. Penrose was a little closer to current thinking by assigning the Boone Chert and what would be Moorefield Shale to the Osagean Group, now Osagean Series, while the Batesville and Fayetteville intervals are assigned to the Genevieve or Boston Group, historically regarded as Meramecian (Fig. 1). Currently, the Fayetteville Shale is regarded as belonging to the Upper Chesterian Series.

The accepted naming and lithostratigraphic correlation of the Moorefield and associated units reflects the work of Adams and Ulrich on the lead and zinc deposits in northern Arkansas, published by the U.S. Geological Survey in 1904 (Fig. 2). Adams and Ulrich (1904) moved the Fayetteville to its proper position, and named the Moorefield Shale, indicating that it succeeded the underlying Boone Limestone unconformably, and was conformably overlain by the Batesville Sandstone (Fig. 2). They also included the Spring Creek Limestone Member at the base of the Moorefield that had been proposed by H.S Williams (1895). Unfortunately, the name Spring Creek was preoccupied by a unit of that name in the Pennsylvanian succession of Texas named by Noah Drake (1893), ironically the third chairman of the Department of Geology at the University of Arkansas. George H. Girty, a well-known U.S. Geological Survey paleontologist, published a description of the fauna of the Moorefield Shale in 1911. He reviewed the lithostratigraphic and chronostratigraphic age assignments for the Moorefield, although he retained the name "Spring Creek Limestone" of Williams (1895), even though he knew it was preoccupied, arguing that its chronostratigraphic importance outweighed an application of priority (Fig. 3). Girty (1911) was equivocal about age assignments for the interval, but concluded that the lower portion of the section, the Spring Creek Limestone, was Meramecian, based mainly on brachiopods. He correlated the higher portions of the Moorefield Shale with the Kaskaskia Limestone/Formation/ Group of Hall, 1857, which became the Chesterian Group of Worthen (1860), and later the Chesterian Series of Worthen (1866).

Mackenzie Gordon Jr. (1944), U.S. Geological Survey, reviewed the stratigraphic relationships of the

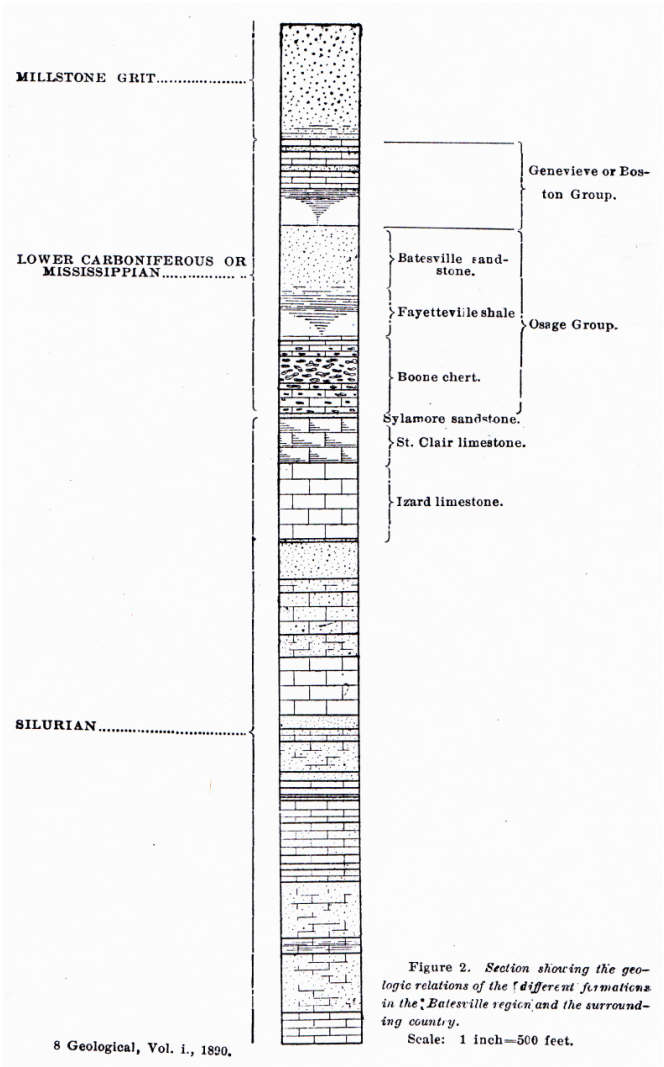

Fig. 1: Stratigraphic Section in the Vicinity of Batesville, Independence County (Penrose, 1891).

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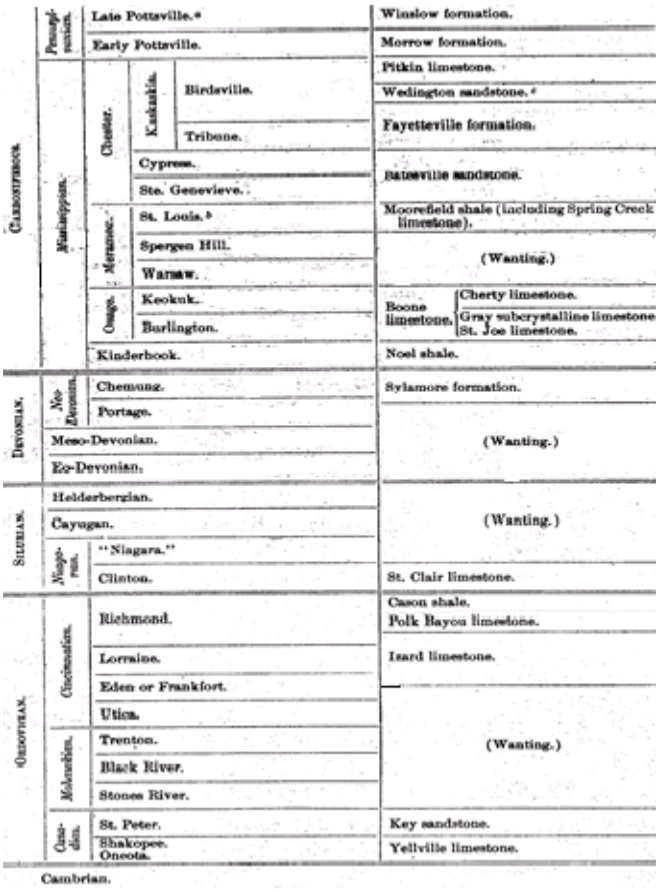
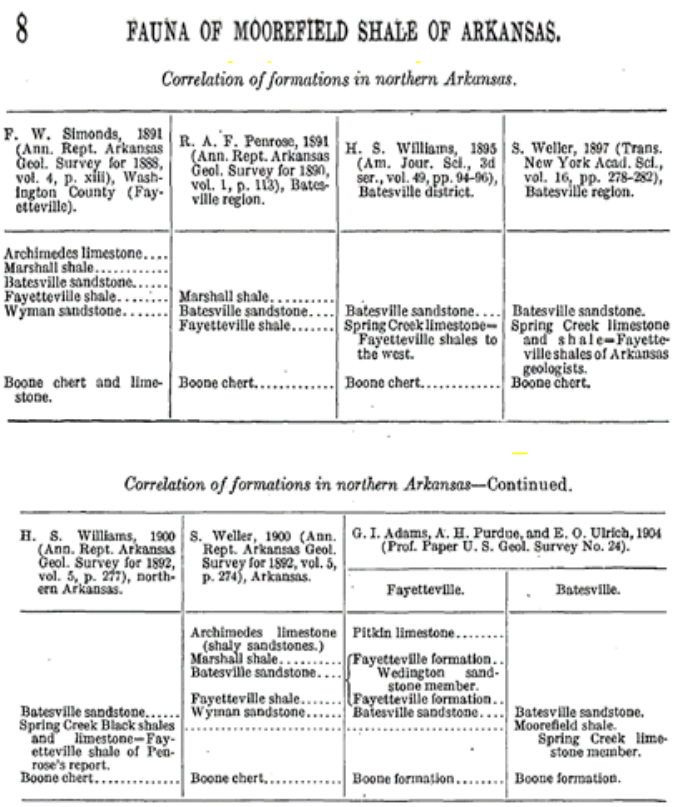


Fig. 2: Stratigraphic Section for the Lead and Zinc Deposits in Northern Arkansas (Ulrich, in Adams 1904).



8 FAUNA OF MOOREFIELD SHALE OF ARKANSAS.

Correlation of formations in northern Arkansas.

F. W. Simonds, 1891 (Ann. Rept. Arkansas Geol. Survey for 1888, vol. 4, p. xiii), Washington County (Fayetteville).	R. A. F. Penrose, 1891 (Ann. Rept. Arkansas Geol. Survey for 1890, vol. 1, p. 113), Batesville region.	H. S. Williams, 1895 (Am. Jour. Sci., 3d ser., vol. 49, pp. 94-96), Batesville district.	S. Weller, 1897 (Trans. New York Acad. Sci., vol. 16, pp. 278-282), Batesville region.
Archimedes limestone....			
Marshall shale.....			
Batesville sandstone.....			
Fayetteville shale.....	Marshall shale.....		
Wyman sandstone.....	Batesville sandstone....	Batesville sandstone....	Batesville sandstone.
	Fayetteville shale.....	Spring Creek limestone—Fayetteville shales to the west.	Spring Creek limestone and shale—Fayetteville shales of Arkansas geologists.
Boone chert and limestone.	Boone chert.....	Boone chert.....	Boone chert.

Correlation of formations in northern Arkansas—Continued.

H. S. Williams, 1900 (Ann. Rept. Arkansas Geol. Survey for 1892, vol. 5, p. 277), northern Arkansas.	S. Weller, 1900 (Ann. Rept. Arkansas Geol. Survey for 1892, vol. 5, p. 274), Arkansas.	G. I. Adams, A. H. Purdue, and E. O. Ulrich, 1904 (Prof. Paper U. S. Geol. Survey No. 24).	
		Fayetteville.	Batesville.
	Archimedes limestone (shaly sandstones.)	Pitkin limestone.....	
	Marshall shale.....	Fayetteville formation..	
	Batesville sandstone....	Wedington sandstone member.	
	Fayetteville shale.....	Fayetteville formation..	
Batesville sandstone.....	Wyman sandstone.....	Batesville sandstone....	Batesville sandstone.
Spring Creek Black shales and limestone—Fayetteville shale of Penrose's report.			Moorefield shale. Spring Creek limestone member.
Boone chert.....	Boone chert.....	Boone formation.....	Boone formation.

Fig. 3: Review of Lithostratigraphic Nomenclature Applied to the Moorefield Interval in Northeastern Arkansas (Girty 1911)

Moorefield interval in the Batesville Manganese District, Independence County. He restricted use of the name Moorefield to the black, calcareous shale and limestone at the base of the interval, previously called the Spring Creek Limestone, and proposed the name Ruddell to designate the succeeding shale interval that comprised most of the section. Gordon (1944) concluded that the restricted Moorefield correlated to the St. Louis Limestone, while the Ruddell was equivalent to the St. Genevieve Limestone, both assigned at the time to the Meramecian of the type Mississippi Valley section. That lithostratigraphic assessment continued into the 1960s, until Gordon (1965) published an extensive description of the Carboniferous ammonoid assemblages of Arkansas that he organized into zones and correlated to the type Mississippi Valley succession (Fig. 4). In this revision, Gordon (1965) regarded the Ruddell as spanning the Meramecian-Chesterian boundary, and interpreted the Moorefield lower and upper contacts as unconformities throughout most of their extent (Fig. 4).

Current Age Assignment of the Moorefield Interval, Northern Arkansas

Current age assignment for the Moorefield Shale is based almost entirely on ammonoid cephalopods (*e.g.* Gordon 1965, Saunders et al. 1977, Korn and Titus 2011). Brachiopods (*e.g.* Girty 1911) have provided a supporting role, but never to the precision of the ammonoids, and neither Moorefield conodonts nor palynomorphs have ever been evaluated. Korn and Titus (2011) reexamined Gordon's ammonoid assemblages, and made additional collections from the type Moorefield. They recognized two Moorefield ammonoid zones: the lower *Goniatites eganensis* - *Girtyoceras welleri* zone, succeeded by the upper *Goniatites multiliratus* zone. The best age assignment of these abundant Moorefield ammonoid assemblages occurring toward the middle portion of that stratigraphic interval is to the lower Chesterian Series (Korn and Titus 2011). Thus, the lower Moorefield Shale, as a low-stand wedge, must certainly span the Osagean-Meramecian boundary, even though barren. The upper section, also barren of ammonoids, and other biostratigraphically useful fossils, is unstudied,

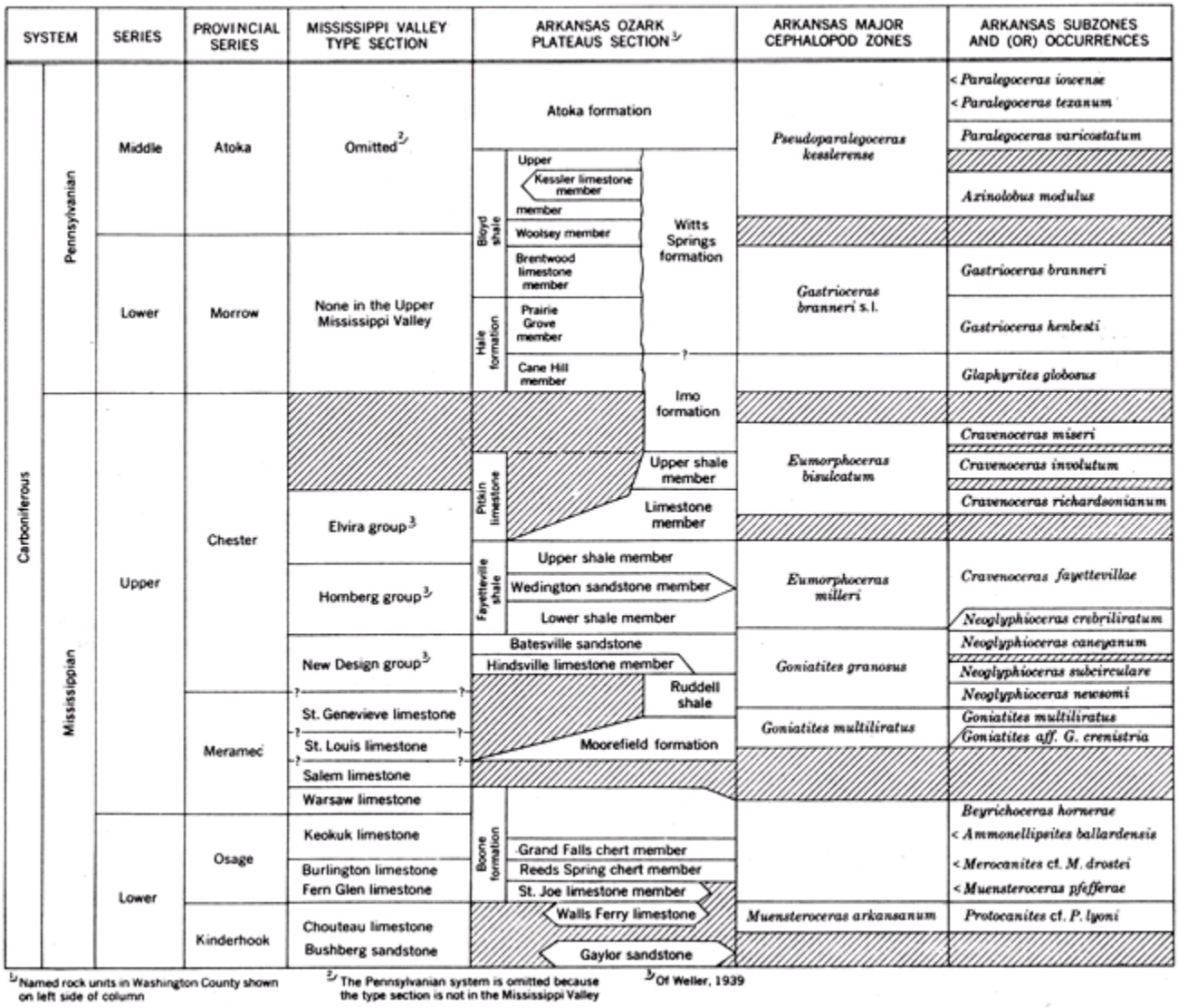


Fig. 4: Biostratigraphic and Chronostratigraphic Correlations for the Moorefield-Ruddell Interval, Northeastern Arkansas (Gordon 1965).

but is no older than middle Chesterian. Therefore, the Moorefield most likely spans the interval from early Meramecian to at least the middle Chesterian; the bulk of the formation represents the Chesterian, not the Meramecian, Series.

Duration of the Meramecian Series

The age assignment of the Moorefield interval is complicated further by a proposal to reduce the lithostratigraphic succession comprising the Meramecian Series (Lane and Brenckle 2005), and a lack of ammonoid assemblages in its type area, St. Louis County, Missouri. Lane and Brenckle (2005) placed the Osagean-Meramecian boundary at the contact of the lower and upper members of the Warsaw Shale. They also lowered the top of the Meramecian Series to the top of the St. Louis Limestone. Thus, the Ste. Genevieve, historically regarded as Meramecian, and which they contend is not present in the type area of the Meramecian Series, becomes part of the Chesterian Series. Consequently, the type Meramecian comprises only the upper Warsaw Shale, and Salem and St. Louis Limestones (Lane and Brenckle 2005).

This interval is zoned on conodonts, but the interval comprises only two zones: the *Gnathodus texanus* zone, which spans the Osagean-Meramecian boundary, and the *Hindeodus scitulus* and *Apatognathus scalenus* zone, which appears in the middle St. Louis Limestone and extends to its contact

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with the *Gnathodus bilineatus* zone in the succeeding Ste. Genevieve Limestone (Lane and Brenckle 2005). Thus, the Meramecian Series has no lower boundary defined by conodonts, and comprises essentially a single conodont zone. In comparison, the underlying Osagean Series and overlying Chesterian Series each comprise all or part of eight conodont zones (Lane and Brenckle 2005). The Meramecian Series must represent only half the absolute time of either the preceding Osagean Series, or succeeding Chesterian Series of the Mississippian Subsystem, and since 1983, the duration of the Mississippian Subsystem has been reduced to the current 35.7 my, a reduction of 4.7 my, for the International Chronostratigraphic Chart (Cohen et al. 2016). Although lacking precise absolute dates, the duration of the Meramecian would appear to be more consistent with a stage, rather than a series.

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