Stratigraphic Cross-section and Discussion of the Mississippian Stratigraphy of Northeastern Mississippi

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Plate 1. Stratigraphic Cross Section of the Mississippian Interval in Northeastern Mississippi . . . . . back pocket

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The Mississippian Stratigraphy of Northeastern Mississippi

Introduction

In 1948 Weller et al. described in detail the difficulties in correlating the Mississippian formations regionally and the problems of nomenclature in use at that time. Again in 1953 Everett addressed the stratigraphic problems of the Mississippian section in the Black Warrior Basin of northeastern Mississippi and northwestern Alabama. Today, more than 60 years later, the available literature concerning the Mississippian stratigraphy in this area may leave the reader with more questions than answers. The confusion seems to have been initiated at a time when there was very little subsurface data available, making it difficult to understand the relationship of the Muldon Clastics to the Bangor Limestone, and the Bangor Limestone to the Neal Shale. As a result, several misconceptions in the correlation of these formations developed, and many authors have carried these ideas forward without realizing that a problem existed. Due to an increase in drilling activity in the 1970's and 1980's, there is now an ample amount of subsurface data to correct these problems. The stratigraphic Cross Section A-A' was constructed to illustrate the relationship of the various Mississippian formations in northeastern Mississippi. It is the authors' hope that this work will provide a better understanding of the Mississippian stratigraphy and resolve the confusion generated by the numerous variations of published stratigraphic columns.

Cross Section A-A'

Cross Section A-A' is a north-south stratigraphic cross section of the Mississippian interval in northeastern Mississippi (Figure 1). It extends 48 miles from the central part of Itawamba County, Mississippi, to the northern part of Lowndes County, Mississippi. Well logs for this cross section were selected on the basis of log quality, even spacing, and the location of the wells being oriented as near north-south relative to one another as reasonably possible. A list of well logs used to construct the cross section is included at the end of the report (Figure 2). Faults were avoided so that a complete Mississippian section could be viewed on each well log used in the cross section. The top of the *Millerella* Limestone was used as the datum for the construction of this cross section.

The Mississippian Stratigraphy

The Mississippian section in the Black Warrior Basin of northern Mississippi can be conveniently divided into six groups. These groups, in descending order, are the Pennington Formation, the Muldon Clastics, the Bangor Limestone, the Hartselle Sandstone, the Pride Mountain Formation, and the Iowa Limestone interval. The Neal Shale is the downdip equivalent of the Bangor Limestone, the Hartselle Sandstone, and at least the upper part of the Pride Mountain Formation. The Floyd Shale, as presented in this report, is considered to be the interval between the base of the Pennington and the top of the Iowa. The Pennington includes the Coats and Gilmer sandstones and *Millerella* Limestone. The Muldon Clastics include the *Millerella*, Carter, Sanders, Abernathy, and Rea sandstones. The Bangor Limestone and Hartselle Sandstone are both individual formations with equivalent basinward shale sections. The Pride Mountain Formation includes the Evans and the Lewis sandstones in the subsurface. The Iowa Limestone interval is primarily the combined undifferentiated Tuscumbia Limestone and Fort Payne Chert, but it also includes in places a thin interval of Maury Shale at the base. Figure 3 is a stratigraphic column comparing the stratigraphy as presented in this report to Dockery's 1997 stratigraphic column of the Mississippian section in northeast Mississippi. A more detailed discussion of these formations and how they relate to one another is given below, although it is not intended to be a complete review of the evolution of the stratigraphic nomenclature. A list of pertinent references is included at the end of this report for the interested reader.

Top of the Mississippian

The top of the Mississippian section is commonly picked at the top of a predominately shale section above the *Millerella* Limestone and at the base of the first prominent sand in the Pennsylvanian. As can be seen on the cross section in the Lowndes and Monroe County area, this is a relatively clear pick, but it is somewhat questionable in Itawamba County. In Itawamba County, as in other parts of the updip areas of the basin, the Pennsylvanian may be entirely eroded away, leaving upper Cretaceous sediments resting directly on Mississippian rocks. In these areas, it is sometimes difficult to pick the top of the Mississippian without the use of well cuttings. For most areas in the downdip portions of the basin, however, the Pennsylvanian-Mississippian contact is a relatively easy pick on induction logs.

Pennington Formation

In Butts' (1926) report on the "Geology of Alabama", he named a section of red shale with beds of sandstone and limestone the Pennington Formation, due to its similarity to the type locality in Virginia and also to its correlative intervals in Tennessee and eastern Kentucky. In the subsurface of northern Alabama and northeastern Mississippi the Pennington was defined by Welch (1958) as the interval between the base of the *Millerella* Limestone and the top of the Mississippian. In several published

stratigraphic columns the Parkwood Formation is substituted for the Pennington. The Parkwood Formation was named for exposures of gray or greenish–gray sandy shale and sandstone that overlie the Pennington Formation in Jefferson County, Alabama. As Butts noted, the Parkwood occurs in a relatively small area in the Shades and Cahaba valleys of the Appalachian fold and thrust belt, and the basal part of the Parkwood is probably equivalent to the upper part of the Pennington in Tennessee. Thomas (1972) placed the Pennington interval as defined by Welch in the Parkwood and expanded the use of the term to include the Muldon Clastics and the Bangor Limestone. Following Thomas, Mancini and others (1983) and Pashin (1994) also included Mississippian formations in the Parkwood other than those as originally defined by Butts and Welch. On the Cross Section A-A' the interval between the base of the *Millerella* Limestone and the top of the Mississippian is designated Pennington as it was defined by Welch, due to its similarity in lithology and stratigraphic position to the Pennington in Tennessee and Virginia. That portion of this interval which would be considered Parkwood by Butts only occupies the upper fifty to one hundred feet of the overall section. There is no clear, consistent point at which to pick the contact between the Pennington and the Parkwood in the subsurface. Even with the use of well logs and cuttings the contact is difficult to pick and is generally unreliable. For these reasons the present authors recommend that the Parkwood Formation name be dropped and the Parkwood interval be included in the Pennington.

Muldon Clastics

As noted by Welch (1958), the appropriate place to pick the base of the Pennington is at the base of the *Millerella* Limestone; likewise, it is also the appropriate place to pick the top of the Muldon Clastics. The Muldon Clastics interval, as it has been informally called in the oil and gas industry for many years, was named for a gas productive interval in Muldon Field, Monroe County, Mississippi. Several authors have indicated on stratigraphic columns that the Muldon Clastics are at least in part, if not entirely, equivalent to the Bangor Limestone, and some of the published lithologic cross sections show the sandstones interfingering with the Bangor. Other authors have indicated on their stratigraphic columns and cross sections that the Muldon Clastics rest directly on top of the Bangor or the high resistivity black (Neal) shale. This discrepancy is possibly one of the main reasons for the confusion in the Mississippian section. Scott's 1978 report on the Bangor Limestone in Alabama and Mississippi, published in a field trip guidebook, did much to correct the stratigraphic discrepancies, but it appears that some of the more recent authors may not be familiar with his work. Scott noted that the Muldon Clastics are younger than the Bangor Limestone and that these clastics share little or no time equivalency with the limestone. He also recognized a channel that had down-cut into the Bangor Limestone during the deposition of the Muldon Clastics, which is indicated on his upper Bangor lithofacies map. The presence of this channel supports Scott's position that the Muldon Clastics were deposited entirely after the Bangor. As can be seen from Cross Section A-A', the Muldon Clastics do not interfinger with the Bangor Limestone, nor they do appear to be equivalent to the Bangor updip or the Neal Shale downdip. The updip unconformity, as indicated by Scott's channel, is intentionally not shown on the cross section so that the reader can view the complete Mississippian

section. The writers recommend the Mississippian section between the base of the Pennington and the top of the Bangor Limestone/Neal Shale, as described by Scott, be formally recognized as the Muldon Clastics.

Bangor Limestone/Neal Shale

The Bangor Limestone was named for rock outcrops in the general area of the town of Bangor, Blount County, Alabama. As the term was originally used by Smith (1890), it included all of the Mississippian rocks above the Fort Payne Formation. Later, in 1926, Butts placed the Bangor between the Hartselle Sandstone and the Pennington in surface exposures. In the subsurface, Everett (1953) correlated the Bangor Limestone in Alabama to the Rea and Abernathy Sandstones in Mississippi. Thomas (1972) developed a conceptualized depositional model for the Mississippian section in which the Bangor included all of the Muldon Clastics in the downdip portions of the basin and also the *Millerella* Limestone. Scott (1978) placed the updip Bangor between the *Millerella* Limestone and the Hartselle Sandstone and downdip between the Muldon Clastics and the Hartselle equivalent shale. Based on his interpretation, he correlated the Bangor Limestone with the downdip Neal Shale, and he placed the *Millerella* Limestone stratigraphically above the Bangor. Everett's stratigraphic section was revised by Cleaves and Broussard (1980) to include all of the Muldon Clastics in the Bangor interval, and they followed Everett in correlating the Neal Shale to the Hartselle. Pashin (1994) presented a generalized cross section showing the upper part of the Bangor equivalent to the downdip Rea and Abernathy Sandstones and the lower part of the Bangor equivalent to the upper part of the Floyd Shale (Neal). He also placed the *Millerella* in the upper part of the Bangor and referred to it as a tongue of the Bangor. The misconceptions of the stratigraphic relationship of the Bangor to the Muldon Clastics and the Neal Shale are evident due to the many variations of published Mississippian stratigraphic sections. As can be seen on the Cross Section A-A', the Neal Shale is a basinward facies of the Bangor. The top of the Bangor Limestone is correlative to the top of the Neal Shale, and downdip the Bangor is entirely equivalent to the upper part of the Neal Shale. As previously discussed, the Muldon Clastics are stratigraphically above the Bangor Limestone/Neal Shale and the *Millerella* Limestone is stratigraphically above the Muldon Clastics. The present authors agree with Scott that the *Millerella* is not correlative to the upper part of the Bangor, nor is the Bangor equivalent to any part of the Muldon Clastics. Accordingly, it is recommended the Bangor Limestone be defined, as it was by Scott in 1978, by placing it stratigraphically between the Muldon Clastics and the Hartselle Sandstone.

Hartselle Sandstone/Neal Shale

The Hartselle Sandstone was named by Smith (1894) for exposures at Hartselle in Morgan County, Alabama. As originally defined, the Hartselle included all of the Mississippian sandstones down to the Bethel (Lewis) with their associated shale and limestone. Butts (1926) restricted the use of the term to ridge-forming sandstones that outcrop to the north of Hartselle, Alabama, and extend from the Morgan-Marshall County

line northwest into the southern part of Colbert County. Butts also recognized the Hartselle in the fold and thrust belt to the east and southeast of the type locality. The Hartselle Sandstone extends into northeastern Mississippi from Alabama, and Merrill (1988), in his report on the geology of Tishomingo County, discussed the occurrence of this formation in detail. Butts placed the Hartselle between the Golconda Limestone (Evans) at its base and the Bangor Limestone above. Welch (1958) placed the Golconda in the Pride Mountain Formation, and as such most stratigraphic sections show the Hartselle immediately below the Bangor and conformably overlying the Pride Mountain Formation or the Evans Limestone. The only controversy between the published stratigraphic sections concerning the Hartselle is its relationship to the Neal Shale. As previously discussed, Cleaves and Broussard (1980) correlated the Hartselle to the Neal Shale, while Scott (1978) placed the Neal Shale entirely above the Hartselle. Later, Pashin (1994) correlated the Neal (Floyd) Shale to the basal part of the Bangor down to the upper part of the Pride Mountain. As indicated on the Cross Section A-A', the Hartselle Sandstone grades quite rapidly to shale in Itawamba County from the outcrop area. Further to the south the Hartselle grades into the basal part of the Neal Shale. The overall section continues to thin southward until the Hartselle is only equivalent to a few feet of Neal Shale toward the southern end of the cross section. The present authors agree with the stratigraphic placement of the Hartselle Formation as defined by Butts and Welch, with the addition of the Hartselle being equivalent to the basal part of the Neal shale downdip.

Pride Mountain Formation/Neal Shale

Butts (1926) applied stratigraphic terminology from the Illinois Basin to sandstones and limestones between the Tuscumbia and Hartselle in northwestern Alabama. These formations, in descending order, are the Golconda Limestone, Cypress Sandstone, Gasper Limestone, Bethel Sandstone, and Ste. Genevieve Limestone. Welch (1958) proposed that this interval be grouped as a single stratigraphic unit named the Pride Mountain Formation for exposures on the northern slope of Pride Mountain in Colbert County, Alabama. Welch further divided this interval into seven members. These members, in descending order, are the Green Hill, Mynot, Sandfall, Southward Springs, Wagnon, Tanyard Branch, and Alsobrook. The Mynot Sandstone is equivalent to the Cypress of Butts, and the Tanyard Branch Sandstone is equivalent to the Bethel. In the subsurface of northeastern Mississippi these members are equivalent to the Evans and the Lewis Sandstones, respectively. Merrill (1988) defined the Pride Mountain Formation as all the strata between the Tuscumbia and the Hartselle. This definition is apparently accepted by other authors, and it is certainly appropriate to continue its use. Just as with the Hartselle, the only variation in the published stratigraphic columns concerning the Pride Mountain Formation is its relationship with the Neal Shale. As illustrated on the Cross Section A-A', the Evans interval grades into the basal part of the Neal Shale, and it appears to conformably overlie the Lewis Limestone. At the southern end of the cross section the Evans is equivalent only to a few feet of the Neal Shale.

Floyd Shale Formation/Neal Shale

The type section for the Floyd Shale is a gray to black fissile shale overlying the Fort Payne Chert in Floyd County, Georgia, as named by Hayes (1891). On outcrop east of Birmingham, Alabama, Butts (1926) noted that the Floyd Shale occupied most of Shades Valley, a broad belt in Coosa Valley, and other parts of Shelby and Calhoun County. He equated the Floyd Shale in this area to the interval from the top of the Bangor Limestone to the base of the Gasper (Lewis), and probably as low as the base of the Ste. Genevieve. In the subsurface of northeastern Mississippi, Welch (1958) placed the Floyd Shale between the top of the Iowa and the base of the Pennington. The term Floyd Shale has been used interchangeably with Neal Shale by some authors, and this has been a source of confusion in the literature. The Neal Shale was named by Scott (1978) for an interval of highly organic shale in the Union Producing Company #1 Neal well in Muldon Field, Monroe County, Mississippi. This shale is easily recognized on geophysical electric logs due to its highly resistive character, and Scott correlated this interval to the Bangor Limestone updip. As previously discussed and as shown on Cross Section A-A', the Neal Shale is a basinward condensed section of the Bangor, the Hartselle, and the upper part of the Pride Mountain. It is stratigraphically below the Muldon Clastics and above the Lewis Limestone. The Neal Shale should be regarded as a member of the more inclusive Floyd interval as defined by Welch.

Fort Payne Chert, Tuscumbia Limestone, and Iowa Formation

The Fort Payne Formation was named by Smith (1890) for rock outcrops located near Fort Payne, Dekalb County, Alabama. As it was originally defined it included an interval of limestone and chert between the Chattanooga Shale and the Hartselle Sandstone. Smith later abandoned the use of the term Fort Payne and further divided this formation into a lower interval that he called the Lauderdale Chert and an upper limestone interval named the Tuscumbia Limestone. Butts (1926) retained the use of the term Tuscumbia, but he reinstated the use of the name Fort Payne in place of Lauderdale Chert, citing wide usage among other authors. The type locality for the Tuscumbia is near the town of Tuscumbia, Colbert County, Alabama, and the formation extends to the west into Tishomingo County, Mississippi. Merrill (1988) described this section in great detail from outcrops in this area. In places the Tuscumbia and Fort Payne have a very similar lithology, and it is often difficult to determine the contact between the two. Welch (1959) noted that many petroleum geologists do not attempt to differentiate the Fort Payne and Tuscumbia and include both units as the Iowa Formation. The Iowa Formation was originally named by Weller (1920) for an interval equivalent to the Fort Payne and the Tuscumbia in the Illinois Basin. Merrill defines the Iowa in northeastern Mississippi as the stratigraphic interval comprising all strata above the Chattanooga Shale and below the Pride Mountain Formation. The term "Iowa" has been widely accepted by most authors for the undifferentiated Fort Payne and Tuscumbia in the Black Warrior Basin in Mississippi and Alabama, and it seems appropriate to continue its use.

Base of the Mississippian

On outcrop in northeastern Mississippi the base of the Iowa Formation unconformably overlies the Chattanooga Shale where present and the Devonian Chert where it is absent. Where data are available, the unconformable contact appears to continue into the subsurface between these two formations. There are, however, relatively few wells that penetrate the full section of Iowa in the area of study as compared with those that terminate in the upper part of the Iowa. Only two wells out of eleven used in the cross-section were drilled deep enough to see the Devonian section. As a result, there is still much to learn about the basal part of the Iowa and the relationship between the Iowa and the Devonian in the subsurface.

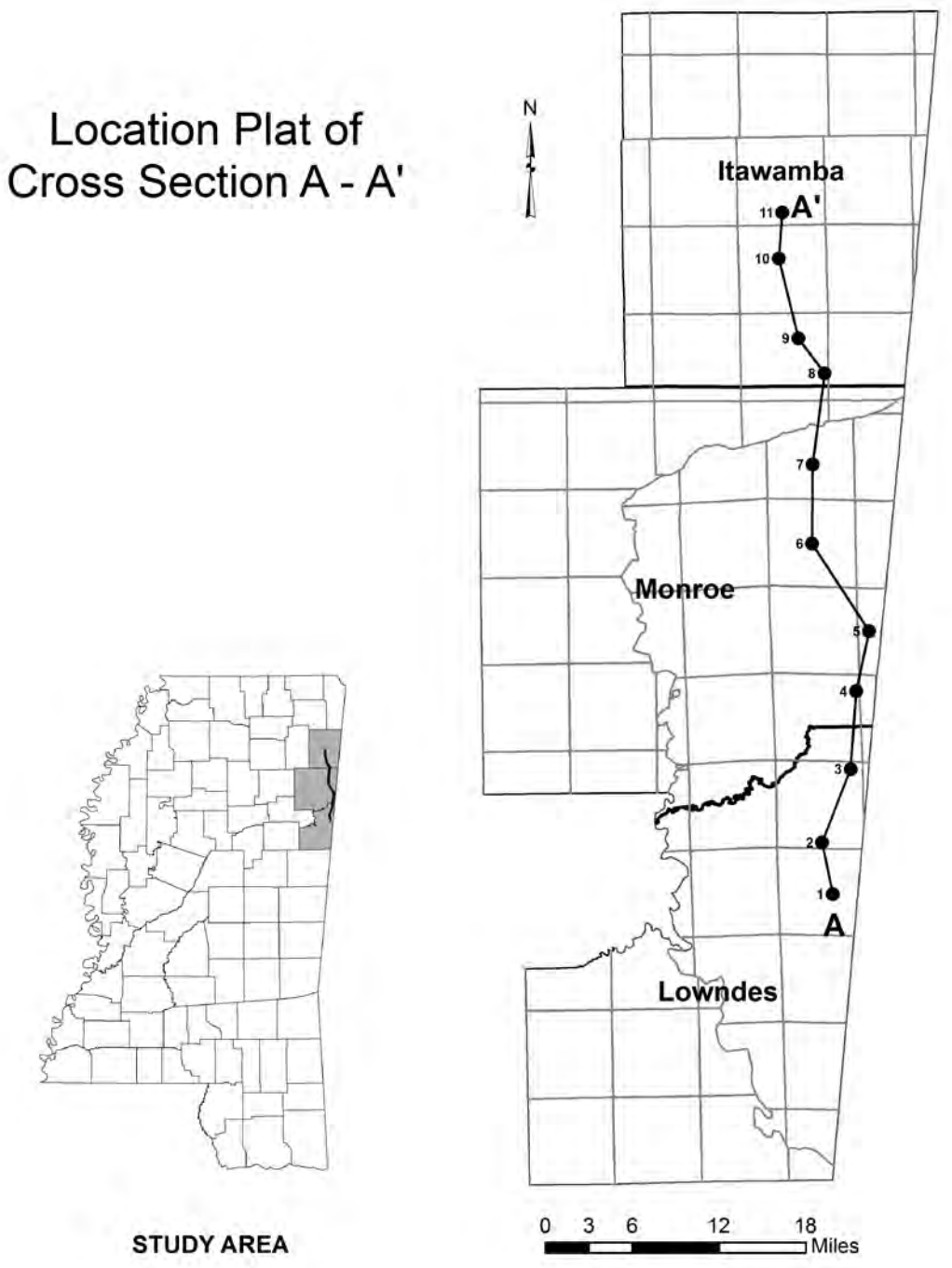
Location Plat of
Cross Section A - A'
N
Itawamba
A'
11
10
9
8
7
6
Monroe
5
4
3
2
1
A
Lowndes
0 3 6 12 18
Miles
STUDY AREA

Figure 1

Well Logs Used to Construct Cross-section A to A'
Northeast Mississippi

Operator	Well Name	Location	County
1. Pruet Prod. Co.	#1 Fulton 22-7	Sec. 22 T17S R17W	Lowndes Co.
2. Pruet Prod. Co.	Wood 34-14	Sec.34 T16S R17W	Lowndes Co.
3. R. L. Burns	Wood 2-1	Sec.2 T16S R17W	Lowndes Co.
4. Pruet Prod. Co.	#1 Coleman 12-4	Sec.12 T15S R17W	Monroe Co.
5. Pruet Prod. Co.	#1 Coats 19-7	Sec.19 T14S R16W	Monroe Co.
6. Energy Three	#1 Weaver 22-4	Sec. 22 T13S R17W	Monroe Co.
7. Terra Resources	#1 Ms. Royalties 22-7	Sec. 22 T12S R17W	Monroe Co.
8. Pruet Prod. Co.	#1 Pierce 25-7	Sec.25 T11S R9E	Itawamba Co.
9. Hagar- Triad	#1 J. R. Moore	Sec.11 T11S R9E	Itawamba Co.
10. C. Dale Armour	#1 A. J Mattox	Sec.16 T10S R9E	Itawamba Co.
11. Rebel Land & Exp.	#1 Spencer	Sec.34 T9S R9E	Itawamba Co.

Figure 2

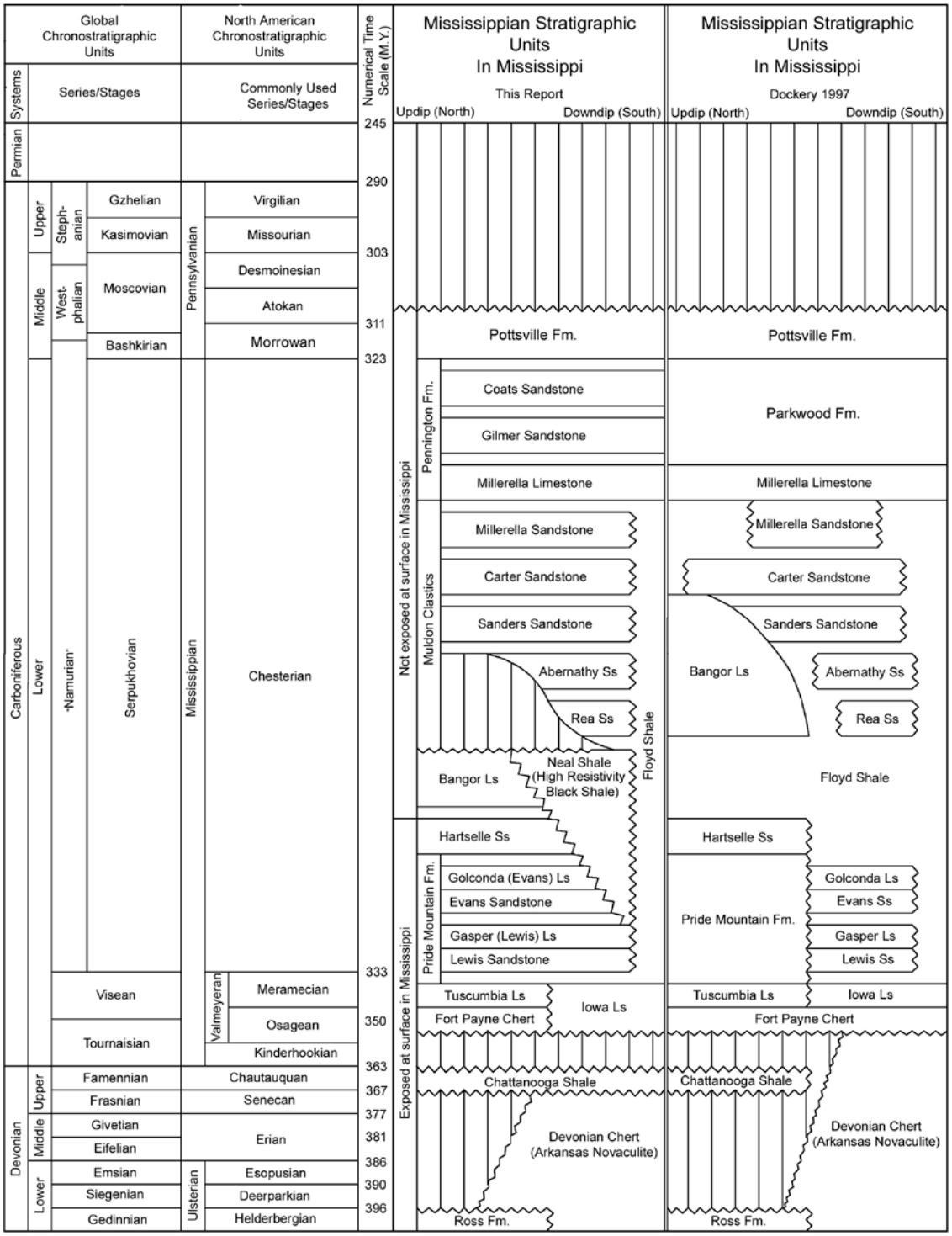
Global Chronostratigraphic Units
North American Chronostratigraphic Units
Numerical Time Scale (M.Y.)
Systems
Series/Stages
Commonly Used Series/Stages
Mississippian Stratigraphic Units In Mississippi
This Report
Updip (North)
Downdip (South)
Dockery 1997
Permian
Carboniferous
Devonian
Upper
Middle
Lower
Steph-anian
West-phalian
Namurian
Gzhelian
Kasimovian
Moscovian
Bashkirian
Serpukhovian
Visean
Tournaisian
Famennian
Frasnian
Givetian
Eifelian
Emsian
Siegenian
Gedinnian
Pennsylvanian
Mississippian
Ulsterian
Virgilian
Missourian
Desmoinesian
Atokan
Morrowan
Chesterian
Meramecian
Valmeyeran
Osagean
Kinderhookian
Chautauquan
Senecan
Erian
Esopusian
Deerparkian
Helderbergian
245
290
303
311
323
333
350
363
367
377
381
386
390
396
Not exposed at surface in Mississippi
Exposed at surface in Mississippi
Pottsville Fm.
Pennington Fm.
Coats Sandstone
Gilmer Sandstone
Millerella Limestone
Muldon Clastics
Millerella Sandstone
Carter Sandstone
Sanders Sandstone
Abernathy Ss
Rea Ss
Bangor Ls
Neal Shale (High Resistivity Black Shale)
Floyd Shale
Hartselle Ss
Pride Mountain Fm.
Golconda (Evans) Ls
Evans Sandstone
Gasper (Lewis) Ls
Lewis Sandstone
Tuscumbia Ls
Iowa Ls
Fort Payne Chert
Chattanooga Shale
Devonian Chert (Arkansas Novaculite)
Ross Fm.
Parkwood Fm.
Millerella Limestone
Millerella Sandstone
Carter Sandstone
Sanders Sandstone
Bangor Ls
Abernathy Ss
Rea Ss
Floyd Shale
Hartselle Ss
Pride Mountain Fm.
Golconda Ls
Evans Ss
Gasper Ls
Lewis Ss
Tuscumbia Ls
Iowa Ls
Fort Payne Chert
Chattanooga Shale
Devonian Chert (Arkansas Novaculite)
Ross Fm.

Figure 3

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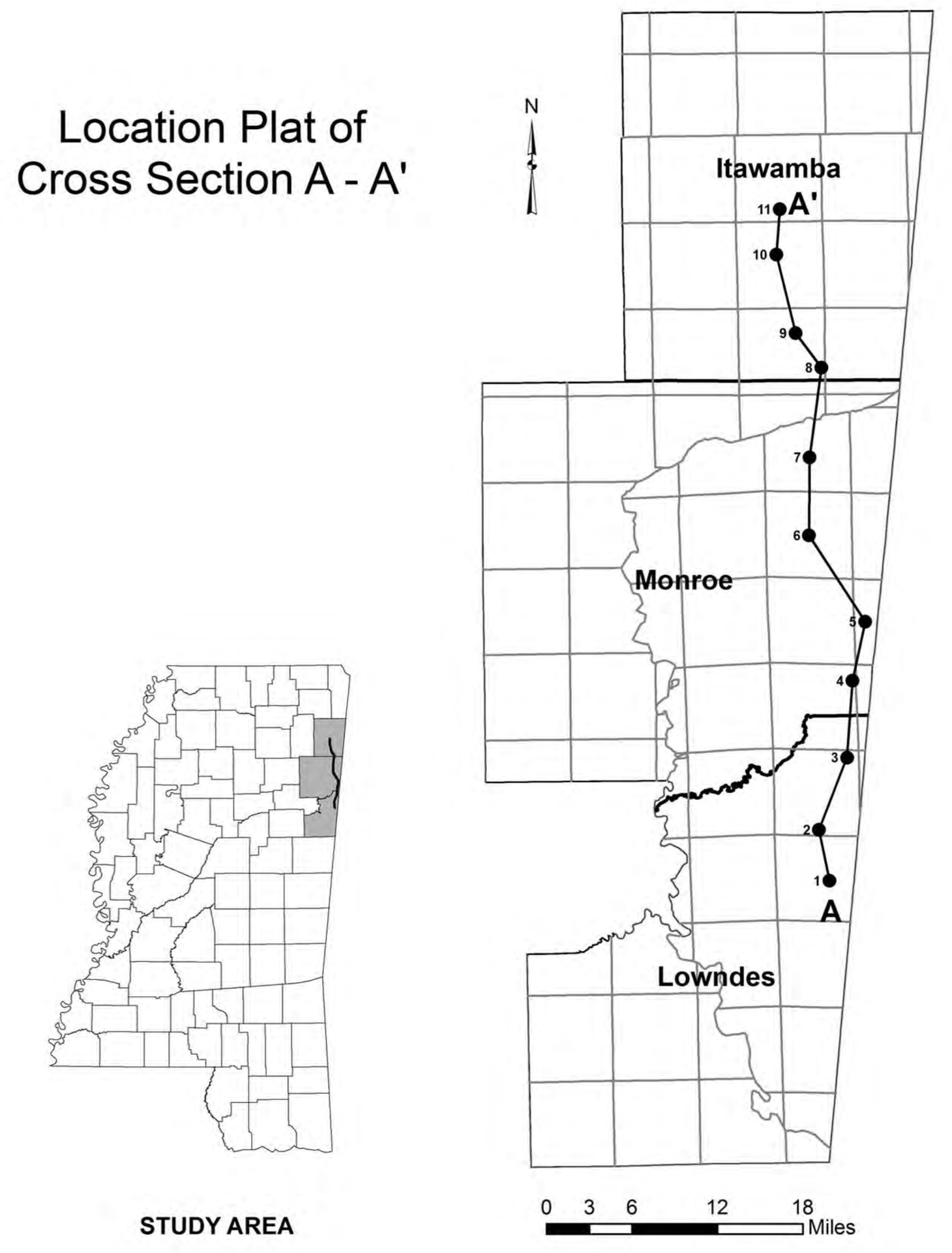
South
A
North
A'
1
Pruet Production Co.
#1 Fulton 22-7
Lowndes County
Sec 22 T17S R17W
2
Pruet Production Co.
Wood 34-14
Lowndes County
Sec. 34 T16S R17W
3
R. L. Burns Corp.
Wood 2-1
Lowndes County
Sec. 2 T16S R17W
4
Pruet Production Co.
#1 Coleman 12-4
Monroe County
Sec. 12 T15S R17W
5
Pruet Production Co.
#1 Coats 19-7
Monroe County
Sec. 19 T14S R16W
6
Energy Three Inc.
#1 Weaver 22-4
Monroe County
Sec. 22 T13S R17W
7
Terra Resources Inc.
#1 Ms. Royalties 22-7
Monroe County
Sec. 22 T12S R17W
8
Pruet Production Co.
#1 Pierce 25-7
Itawamba County
Sec. 25 T11S R9E
9
Hagar-Triad-Baker-Holman-Marline
#1 J.R. Moore
Itawamba County
Sec. 11 T11S R9E
10
C.Dale Armour & W.J. Runyon
#1 A.J. Mattox
Itawamba County
Sec. 16 T10S R9E
11
Rebel Land & Exploration
#1 Spencer
Itawamba County
Sec. 34 T9S R9E
Datum
Base of Pennsylvanian
Top of Mississippian
Pennington Fm.
Coats Sandstone
Gilmer Sandstone
Top of Millerella Limestone
Millerella Sandstone
Carter Sandstone
Sanders Sandstone
Abernathy Sandstone
Rea Sandstone
Muldon Clastics
Top of Neal Shale
Top of Lewis Limestone
Top of Iowa Limestone
Top of Devonian
Muldon Clastics
Evans Equivalent
Top of Neal Shale
Bangor Equivalent
Top of Bangor Limestone
Hartselle Equivalent
Top of Evans Limestone
Pride Mt. Fm.
Top of Lewis Limestone
Top of Iowa Limestone
Top of Devonian



Mississippi Department of Environmental Quality
Office of Geology
In Cooperation with the Office of Land and Water Resources

Open - File Report 276

Michael B. E. Bograd
State Geologist

Plate 1

Stratigraphic Cross Section A-A' of the Mississippian Interval of Northeastern Mississippi

by Lindsey Stewart & Jonathan R. McMillin

May 2015

Hoizontal Scale: 1 inch = 1mile
Vertical Scale: 1 inch = 200 feet

This cross section prepared under the supervision of James H. Hoffmann, RPG.

REGISTERED PROFESSIONAL GEOLOGIST
MS
0257
JAMES H. HOFFMANN

James H. Hoffmann

James H Hoffmann, RPG
April 10, 2015