Paleontology of Upper Mississippian/Lower Pennsylvanian rocks in Eddyville, Stonefort, and Creal Springs Quadrangles, Southern Illinois

Unpublished manuscript by Joseph A. Devera, circa 1987

This manuscript turned up while sorting through files in my office on July 5, 2018. Portions of this manuscript were incorporated into ISGS Bulletin 96, which covers the geology of this area (parts of Johnson, Saline, Pope, and Williamson Counties). Included also are two memos concerning a Pennsylvanian goniatite locality.

John Nelson 7/5/18

PALEONTOLOGY OF UPPER MISSISSIPPIAN/LOWER PENNSYLVANIAN ROCKS IN EDDYVILLE, STONEFORT AND CREAL SPRINGS

by Joe Devera

INTRODUCTION

Recognition of specific Chesterian formations within the study area can be difficult because these rocks are usually poorly exposed and are structurally scrambled, leaving only incomplete rock sequences. Other difficulties exist in the similarity of lithologies within Chesterian rocks. These sandstones and limestones associated with shales represent the remnants of cyclic terrestrial/marine environments which, in effect, created the redundant rock types. The paleontology, at first glance, also appears to repeat itself within similar lithologies. This is due to the multitude of facies fossils which in life followed their respective environments through time and reoccur in similar rock types up and down section.

Distinguishing characteristics do exist. In the Chesterian Series, rapid speciation of the crinoid *Pterotocrinus* has been documented (Sutton, 1934 and Gutshick, 1965). Significant changes in shape and size of the wing plates of this genus were found to be quite common in Chesterian limestones. Along with *Pterotocrinus*, conodonts and foraminifera are useful for stratigraphic discrimination. There are drawbacks to biostratigraphy. This type of detailed work takes time when mapping. Key guide fossils are not always found or may not be present in certain locations.

We applied practical paleontology, the law of superposition, and in most cases detailed lithologic descriptions to distinguish Mississippian formations and members.

Practical paleontology employs inductive reasoning and common fossil occurrences. For example, the use of peak zones or the abundance of a single species to a particular horizon can be used to correlate some of the upper Chesterian formations because the fossils make up a certain lithologic character of the rock. Assemblage zones or occurrences of overlapping ranges of different species are also helpful.

Some of these practices have been well established by previous authors. For instance, a general premise based on a large number of observations by many workers states "the lower part of the Negli Creek Member of the Kinkaid Formation commonly has oncoids of Girvanella (an encrusting blue green algae) and large belerophontid gastropods (20-30 mm) which typically occur together in a dark gray lime mudstone" (Swann, 1963; Gutshick, 1965; Randall, 1970; Atherton et al., 1975; Buchanan, 1985; also commonly observed by us). This is not to say that Girvanella and the large gastropods only occur in the lower Negli Creek or only at this time. Girvanella and the belerophontid gastropods are both long ranging. They can be found in underlying and overlying members and formations. However, they have not been documented together in underlying and overlying formations. Belerophontid gastropods are found in the overlying Cave Hill Member. Here, they are small (4 to 5 mm in diameter). These gastropods are also found in the Ford Station and Cora Members of the underlying Clore Formation and like the Cave Hill gastropods, they are small and are not associated with Girvanella. The Girvanella/belerophontid association is unique because certain environmental conditions must have been present over a wide area of the Illinois Basin. It is a useful marker and reliable for correlating with the basal part of the Negli Creek throughout the study area where the lower Negli Creek is exposed.

This and other examples of practical paleontology are only helpful when correlating locally within the Illinois Basin. Fossils like color, weathering characteristics, and bedding, are distinguishing features of the rock.

Clore

Paleontology and Deposition Setting of the Clore in Eddyville, Stonefort and Creal Springs.

The Clore is rarely exposed within the study area. The paleontology of this formation will only briefly be discussed. Paleoenvironments of the Clore are primarily inferred from the paleoautecology of the fossils found and projected from well exposed areas just south of the study area in the Waltersburg and Glendale quadrangles.

The only recognized exposure of Clore within the study area was found in the Stonefort Quadrangle. The outcrops yielded two types of fenestrate bryozoans, Archimedes sp. and Polypora sp, a twig-like bryozoan called Rhombopora, the brachiopods Composita subquadrata and Spirifer sp., silicified rugose corals belonging to the genus Triplophyllites and numerous pelmatozoan fragments (see Plate #1). These fossils are of no stratigraphic value. They are useful for environmental reconstruction. The Clore was identified on the basis of stratigraphic position and lithologic character, not fossil content.

Abegg (1986) found that the most common bryozoan genera within the Clore are Archimedes and Rhombopora (previously called "Batostomella"). However, these bryozoa occur throughout the Chesterian Series. Archimedes required harbored habitats with low to moderate turbulance (McKinney and Gault, 1980). Their delicate fronds could not withstand open highly turbulent water, but Archimedes needed mixing to obtain nutrients dispersed in sea water. It could not survive in restricted or stagnate water (McKinney and Gault, 1980). McKinney and Gault (1980) found that the optimum environment for Archimedes was probably leeward of shoals.

At the Stonefort locality, some fronds of Archimedes were found still attached to the calcified screws in the Clore. The Archimedes were buried by argillaceous carbonate sediment and are near their growth area. Detached Archimedes screws are common in the Chester Series. These calcified spirals can be transported large distances from their growth sites post mortem. When found detached from their fronds they occur in a variety of microfacies and are not very useful. The Archimedes occurring in the Clore at the Stonefort locality probably grew in a low turbulence environment.

Composita subquadrata displays an adaptation to the problem of feeding in low turbulent water. It has a well developed sulcus and fold which functions to separate food bearing water from food filtered water (Fig. 1).

The Clore in this area has a soft muddy substrate as shown by the presence of clay and spiriferid brachiopods. The eleongate valves of these articulate brachiopods are well adapted for soft stratum. The broad hinge line distributes body weight like a snowshoe.

Rugose corals can and typically grow on soft muddy substrates. They are commonly found in shales and shaly limestones of the Chester Series. Rugose corals occur in patches within the Clore. Trilophyllites spinulosum is the only species of rugose coral that has been reported from this formation (Abegg, 1986). Several silicified Trilophyllites were found in the Clore. None were in life position.

The most dominant faunal elements of the Clore in this area are pelmatozoa and articulate brachiopods. We assume this limestone is the uppermost member of the Clore, the Ford Station, because it occurs below the Degonia Sandstone. The depositional setting of this exposure was normal marine, back barrier lagoon not restricted with low rates of sedimentation.

Degonia

The paleontological information is sparce from the study area on the Degonia. Bioturbation within the Degonia Sandstone was found in a streambed

(SE 1/4, Sec. 35, T.11S., R.4E.), Stonefort Quadrangle. Trace fossils found were tubular shaped structures, non-branching, horizontal, produced by infaunal sediment feeding organisms. These ichnofossils are indicative of either marine or non-marine conditions. In the Eddyville Quadrangle along a cut bank of Lusk Creek (NW 1/4, SE 1/4, NW 1/4, Sec. 3, T.12S., R.6E.) prominent current ripples show deposition of the Degonia under directional subaqueous conditions. In the Waltersburg Quadrangle immediately south fossil plants and crawling traces have been observed in the Degonia.

The Degonia was deposited in nearer shore environments than the Clore. In other areas coal has been found in the Degonia. The presence of varigated red and green shales near the top of this formation may represent paleosols which can be seen at the Lusk Creek locality (SE Eddyville Quadrangle) and in most areas above the fine grained thinly bedded sandstones and siltstones of the Degonia.

Negli Creek Member of the Kinkaid

The Negli Creek is the basal resistant limestone member of the Kinkaid Limestone. Rare outcrops of the Negli Creek are found in the Eddyville and Stonefort Quadrangles. This unit was not found in the Creal Springs Quadrangle. Features common to the Negli Creek are massive bedding, chert lime mudstones, wackestones and packstones. Carrozyi and Roche (1968) worked on detailed petrography of the Negli Creek at the type section in southern Indiana and Buchanan (1985) also worked on the petrography of this member just south of the study area. They found that the Negli Creek is composed of a lower skeletal wackestone and packstone facies, whereas the upper parts are made up of primarily packstone and grainstone facies. The lower facies have the Girvanella/belerophontid association and the Chaetetella Zone, which is recognized in southern Illinois, southern Indiana and western Kentucky (Trace and McGrain, 1985). Chaetetella is a very reliable marker for the lower Negli Creek. Chaetetella has only been reported from this member and has a narrow stratigraphic range within the lower part of the Negli Creek.

The upper Negli Creek facies has a higher amount of bioclastics than the lower facies. The upper facies is primarily composed of pelmatozoa and fenestrate bryozoa and minor constituents are articulate brachiopods, trilobites, foraminifera, ostracodes and corals. Taphonomic characteristics of the upper Negli Creek facies differ markedly from the lower facies in that most body fossils show a high degree of disarticulation and abrasion. This is probably due to higher energy conditions and transportation of skeletal grains in the upper facies.

Both lower and upper facies of the Negli Creek were found in the study area. Fossils typical of the upper Negli Creek facies were observed on a hill along a horse trail (NW 1/4, SW 1/4, Sec. 3, T.12S., R.6E. and center of Sec. 4) in the Eddyville Quadrangle. A packstone containing fenestrate bryozoans, Archimedes and an abundance of pelmatozoans and brachiopods all disarticulated and fragmented were found. Just below the hill, outcrops of the Degonia Sandstone were observed. In the Stonefort Quadrangle the lower facies of the Negli Creek was found (20 ft from the south line and 200 ft from the east line at Sec. 35, T.11S., R.4E.). A limestone containing the index fossil Chaetetella was observed. Exposures of the upper Negli Creek were also found in Sec. 2, 400 ft from the north line and 400 ft from the east line, T.12S., R.4E., Stonefort Quadrangle. At this location the limestone is composed of a fossil hash. Crinoid and bryozoan debris being the most abundant bioclastic component of the rock. Bedded chert from black to dark gray is present at this site.

The depositional environment of the lower Negli Creek facies in the study area represents a shallow warm open marine shelf. Low to moderate turbulance in the form of ossilation waves was a prevalent element in the environment. Ossilation facilitated slight rolling of bioclastic grains which were encrusted by filamentous blue-green algae (Girvanella) that made concentric laminae and produced oncoids. Directional sea currents that were present were not strong enough to remove the large quantities of lime mud in the study area.

Stronger currents existed in the upper Negli Creek facies to produce the skeletal packstones and grainstones. Higher energy, shoaling environments existed on the shelf at this time. Therefore, the upper Negli Creek facies reflects a shallower nearer shore environment than the lower Negli Creek facies.

Cave Hill Member

The Cave Hill Member is fossiliferous and quite shaly. A peak zone of Myalina occurs just a few feet below the top of the Cave Hill. This was originally reported by Lamar (1925) and later by Randal (1970). Myalina was a sessile oyster-like organism that formed a mat in a very shaly limestone and is commonly associated with the bivalve Edmondia. Occasionally, the isotrophid edrioasteroid Neoisorophusella lanei (Kammer, Tissue and Wilson, 1987) is found encrusting on the myalinids. However, N. lanei has not been observed in the study area. So far, it has been limited to an area west within the Buncombe Quarry, but may have spotty occurrences elsewhere. The Myalina - Edmondia zone is common in many areas.

Generally, the most abundant coral found within the Cave Hill is the horn coral Triplophyllites palmalus. Kinkaida trigonalis and Caninostrotian variabilis are more localized westward and are not found in the study area. Crinoids include a few species of Pterotocrinus and Graphocrinus and the blastoid Pentremites. Common molluscans are the enomphalid gastropod Platyceras and a dwarf species of Belerophon.

There are several exposures of the Cave Hill Member within the Eddyville and Stonefort Quadrangles. No outcrops of this unit were found in the Creal Springs Quadrangle. A Cave Hill outcrop along Caney Branch (NW 1/4, NE 1/4, SW 1/4, Sec. 11, T.11S., R.6E) in the Stonefort Quadrangle was confirmed by drilling. Exposure was near the mid-portion of the member. Fossils observed were mainly pelmatozoans and bracnhiopods in thinly bedded, yellowish-orange weathered, shaly wackestone. An Archimedes with fronds attached to the coiled axis was found flattened along the bedding planes in the shale layers. Spirifer increbescens and Composita sp. were the most common brachiopods that were observed. In the limestones the fronds of Archimedes were detached and the calcified axes were typically found to be encrusted by the fistuliporid bryozoan Eridopora sp.

In the Eddyville Quadrangle, in a large ravine, on the south side of Ramsey Branch (Sec. 4, T.12S., R.6E), highly fossiliferous thin limestone slabs yielded Spirifer increbescens, Composita, Fenestella sp. and Archimedes screws. Cave Hill exposures were also found in a south-trending ravine just southwest of the center of Sec. 35, T.11S., R.6E., in the Eddyville Quadrangle. Here, spiriferids, Composita sp., and the spiney productid brachiopod Diaphragmus sp. were found along with Archimedes screws and a profusion of pelmatozoans.

The depositional setting of the Cave Hill Member represents restricted near-shore habitats that were intertonguing with open shelf habitats. Terrigeneous muds mixed with limestones reestablished similar environments that were seen in the Clore. Hence, similar organisms like Archimedes, spirifirids and compositids were in situ and found intact. Like the shaly

Clore strata, the Cave Hill also reflects a harbored depositional environment. Where the limestone is prevalent, the taphonomy depicts higher energy conditions with disarticulated Archimedes screws that were stabilized by encrusting fistuliporid bryozoans. Many of the brachiopods and corals do not appear to be in life position within the wackestones of the Cave Hill. Other fossils that were observed in the limestones of the Cave Hill were disarticulated plates of the crinoids Plentocrinus sp. and Agassizacrinus dactyliformis Pentremites sp., Spirifer increbescens Composita sp., Eridospora sp., and abundant pelmatozoans (see Plate 1).

Within the shales of the Cave Hill Diaphragmus, Trilophyllites palmatus, articulated Archimedes, and rare articulated fossils of Pterotocrinus and Graphiocrinus can be found. Many other fossil varieties have been found in the Cave Hill, but were not observed in the study area.

Goreville Limestone Member

The Goreville Limestone is the uppermost massive member of the Kinkaid Limestone. Typical body fossils of the Goreville are large (2 to 3 ft long, 1 to 2 inches in diameter) Archimedes screws, shark pavement teeth and a large rugose coral Caninostration variabilis. This member was found in only one location within the Stonefort Quadrangle (loc?). In most places within the study area the Goreville is not exposed because of overlying Pennsylvanian sandstones covering or cutting this unit out.

The paleoenvironment of the Goreville was greatly affected by a rise in sea level, shifting habitats back to open shelf conditions. High energy holomaxine environments returned with the transgression.

Part 2. Pennsylvanian Rocks

Introduction

The primary problem of mapping lower Pennsylvanian rocks in the Illinois Basin is the differentiations of sandstones into well defined formations. Lithology, superposition and lateral relationships of sandstone bodies were the primary tools used to distinguish facies in the field. Paleontology of these rocks were based on palyanology, vascular land plant impressions and rare occurrences of amminoid cephalopods, foraminifera and conodonts. Mainly biostratigraphy of fossil spores was used to correlate and test some of our formaton "picks." This was not accomplished in the field. The important paleontological field tool for local correlation was the use of trace fossils. Besides distinguishing local correlations, ichnofossils aided the identification of marine sandstones and non-marine sandstones.

Ichnofossils are fossilized traces of animal behavior preserved in the actual paleoenvironment. Trace fossils are significant because many trace making organisms have a narrow facies range, represent in situ paleocommunity (are rarely if ever reworked), and provide location and spacing of the benthic community. They are not good biostratigraphic indicators although ichnofossils do make good local marker horizons (peak zones) that have been correlated across some of the quadrangle mapped. The most significant contribution of trace fossils to our mapping was that the marine varieties commonly occur in medium to thin bedded sandstones, siltstones and shales where invertebrate body fossils typically do not. Three locations, two in Eddyville and one in Creal Springs yielded body fossils in lower Pennsylvanian siliciclastics whereas over 34 locations containing ichnofossils from both marine and non-marine siliciclastics were observed in the study area.

Thus far the ichnofaunal list from Eddyville, Stonefort and Creal Springs include: Conostichus, Zoophycus, Rhizocorallium, Asterosoma, Cochlichmus, Pelecypodichmus, Torrowangea, Beaconichmus, Tasmanadia, Chondrites,

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Fig. 2. Bristol and Howards Paleochannel Cartoon

Plate 2. Ichnofossils

Aulichnites, Teichichmus, Stellascolites (?) Tasmanadia, Phycodes, Petromonite (?), Scolithus, Granularia, Scolicia and two other unnamed trace fossils (see Plate 2).

Wayside Member

The Wayside is a complex lithologic package containing massive fine grained pure quartzose sandstone facies, thin bedded siltstone facies, lenticular quartz-pebble conglomerate facies, gray shale and coal facies with rooted zones, and rare black shale facies with marine fossils. These lithologies are usually overlain by the bluff forming Battery Rock Sandstone.

During the deposition of the Wayside a deltaic system was prograding over a well developed paleochannel system which had been carved into the upper Chesterian rocks. The earlier paleochannels were latest Mississippian in age (Fig. 2). Their development was in response to a worldwide lowering of sea level (Ross and Ross, 1985?). Limestone conglomerates are evidence of this early paleochannel development. These conglomerates have been found just south of the study area in the northern part of the Glendale Quadrangle near a deep channel that has cut down to the top of the Clore Formation. The Wayside is quite thick in the paleochannels and can get up to about 180 feet thick. In the deeper parts of the paleochannels the Wayside is composed of basal lenticular quartz pebble conglomerates. The conglomerate facies have poorly preserved lycopod logs, reworked corals and crinoid stems from the upper Chesterian limestones. Invertebrates from the conglomerate facies of the Wayside are typically abraided, fragmented and disarticulated. This facies probably represents distributary channel lags forming in the basal parts of the Wayside. This lithology resembles the overlying Battery Rock and Pounds members of the Caseyville.

The thin to medium bedded fine grained quartzose facies makes up the bulk of the fill within the paleochannels. This facies is typically white to light brown,w ell sorted, fine grained, clean, semi-friable to friable quartz sand. Distinct cross bedding with a dominant southwest direction is commonly observed. Occasionally thinner beds of the same lithology are seen with clay partings between the sandstone beds. Small reworked pelmatozoans are found in these clay partings.

The thin to medium bedded, fine grained lithofacies is interpreted as being point bar and transvers bar deposits. This is the main body of the distributary channels. Within the study area, no in situ marine fossils were found in the facies of the Wayside. Plant fossil debris is common. In other areas south and west of these quadrangles marine sandstones and shales have been found.

A thin bedded siltstone facies was observed both laterally and overlying the thick, fine grained, thin to medium bedded lithofacies. In the Stonefort Quadrangle (locations 753, 755 and 769) and location 286 in the Eddyville Quadrangle, the siltstone facies was found to be composed mainly of thin bedded, ripple marked siltstones with abundant horizontal feeding and crowding burrows and a few escape burrows inclined to bedding. Thin lenticular coals with plant fossil debris are also associated with this facies. The bioturbation consists of simple horizontal branching and curving tubes found as hyporeliefs or crawling trails found on the rippled surfaces.

These thinly bedded siltstones probably represent floodplain on over bank deposits. The flaggy nature of this facies depicts high energy currents from flood stages the occurred in the distributary channels. Shallow water features and subaerial features have also been observed in the flaggy siltstones south of the study area in the Waltersburg Quadrangle. Micro ripples and deltas and mudcracks are all indicative of shallow water and eventual drying of the floodplain. Ichnofossils also support the non marine hypothesis for this facies.

Within the study area, no marine facies were found; however, south and west of this area, where the Wayside is completely exposed in Glendale and Lick Creek Quadrangles, marine invertebrates have been found in the shale and sandstone facies. So, some of the paleochannels containing Wayside may have become inundated by marine water during lower Pennsylvanian time, but have not been exposed in the study area.

Battery Rock Sandstone Member

The Battery Rock consistently maintains 10 to 20 foot benches and up to 50 foot bluffs composed of primarily two facies: (1) a massive poorly sorted, iron rich quartz pebble conglomerate, and (2) medium bedded well sorted, sugary, quartz sandstone with high angle cross bedding and rare quartz pebbles.

Paleontology is limited to large vascular plants found as transported logs of Lepidodendron and Calamites. No other fossils have been found in this member, within the study area. A trace fossil identified as Skolithos was found just south of the Stonefort Quadrangle, near the Illinois Central Railroad tracks within the Battery Rock (NW 1/4, NW 1/4, Sec. 17, T.12S., R.4E.). Skolithos is a vertical burrow and a large number of them were found at this locality. They appear to be escape structures. They are iron stained and terminate with a circular opening at the top of the bed.

The massive poorly sorted quartz pebble conglomerate facies is proportionally the most common facies of the Battery Rock. It represents distributary channel lags, and was probably formed by several anastomosing channels. In most areas studied this facies is found as a blanket like deposit which was created by lateral shifting channels. However, ledges composed of this facies in the Stonefort Quadrangle were discontinuous and bedding was highly variable with lenticular units and scour and fill structures. At one location (Stonefort 187) coal stringers were found at the base of the ridge of this massive conglomeratic facies.

The second facies is composed of moderately well sorted quartz sandstone with high angle cross bedding. This facies is not commonly preserved but is thought to represent bar deposition above the massive lag facies. Bars are either point bars or transverse bar deposits within the anastomosing distributary channels. The appearance of vertical tubes in both facies of the Battery Rock also supports these depositional environments.

Drury Member of the Caseyville

The Drury Member is found above the ridge forming Battery Rock Sandstone and below the Pounds Sandstone. Lithologically, the Drury is quite diverse. It is locally composed of black shales, medium gray shales, thin bedded fine to medium grained sandstones, laminated siltstones, and flaggy fine grained silty sandstones. Thin and laterally discontinuous coals are found within this member and one limestone bed (previously called the Sellers Limestone Member) also occurs in the Drury east of the study area, at Sellers Landing, Hardin County, Illinois. No limestones were found in the Drury within the three quadrangles studied.

Like the Wayside Member, the Drury is composed of a complex package of a number of lithofacies. In places (southern portion of Stonefort Quadrangle and extending into the northern part of the Glendale Quadrangle), the Pounds Sandstone cuts out the Drury Member and merges with the Battery Rock. In other areas, the contacts between the underlying Battery Rock and overlying Pounds are gradational. These transitional contacts were observed in a core

Fig. 3. E4 Core diagram and description

Fig. 4 and 5. Fig. 4. Locations of Core E4, marine shale and lateral facies. Fig. 5. Measured section of Hays Creek horse trail.

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taken north of Bear Branch Creek 1.5 miles east, northeast of Eddyville, Illinois. Hence, the Drury consists of an 82 foot black to dark gray shale (Fig. 3). Two miles southwest of this black shale facies the lithology grades laterally into thin bedded laminated siltstones, thin gray shales and fine grained flaggy sandstone beds along a horse trail crossing Hayes Creek just west of Eddyville (Figs. 4 and 5). Farther west, at Peter Cave, in extreme southwestern Eddyville Quadrangle, the Pounds is found disconformably above a light yellow, very fine grained, massive sandstone unit with herringbone crossbedding. In the Creal Springs Quadrangle, shales interbedded with siltstones and sandstone conformably overlie the Battery Rock (Sec. 3, T.12S., R.4E.).

The contacts between the Pounds, Drury and Battery Rock members are complex as a result of the many different depositional environments found along this deltaic system. We have seen in areas like Bear Branch to Petes Cave in southwestern Eddyville Quadrangle where the Drury becomes a lateral facies of the lower Pounds and can become indistinguishable from the lower Pounds or upper Battery Rock.

Plate 3. Pennsylvanian body fossils

There are five basic facies of the Drury: (1) black shale facies; (2) medium gray shale facies; (3) fine grained flaggy carbonaceous silty sandstone facies; (4) laminated siltstone facies, and (5) a fine grained, herringbone crossbedded sandstone facies.

The black shale facies outcrops along a north flowing tributary to Bear Branch Creek. This shale was found at three location (Fig. 4) and one cored location just 1.5 miles east of Eddyville. This black shale facies is confined to an area in southwestern Eddyville Quadrangle and was not found in Stonefort or Creal Springs. However, it is a significant facies. The black shale bears a marine fauna including the goniatites Axinolobus sp., two different species of Gastrioceras, Wiedezoceras (?) (see Plate 3), straight nautiloid cephalopods, bivalves and gastropods, articulate and inarticulate brachiopods, conodonts and 49 different species of palynamorphs (Devera et al., 1987). The fauna appears to be dominantly molluscan. The age of this marine black shale has to be at least as old as Westphalian A (late Morrowan) because of the absence of Endosporites and the presence of Axinolobus.

Out of the 350 goniatite cephalopods found only a few (15) represented the adult population. Most of the goniatites found were juvenals. A dwarf population was ruled out because most sutures observed showed young ontogenetic stages of development. It has been proposed that mature goniatites deposited their eggs in the low energy dysaerobic environments, during times of normal salinity, within estuaries, near shore lagoons and bays

(Mapes ?). This effort was to lower predation of the young goniatites who could withstand the harsher brackish, dysaerobic times of estuarine life.

Other evidence to support this depositional model for the black shale was the linear geometry of the shale facies, the gradational nature of the contacts above and below and laterally to the black shale, abundance and diversity of the terrestrial fossil plant spores and fossil plant detritus. The high percent of organic carbon (1.7%) and marcasite replacement of many of the fossils indicate dysaerobic conditions that probably existed in the deeper portions of the estuary or drown distributary channel. Whereas the dark gray to medium gray shale facies that sandwiched the black shale in, as seen from the core (E4), show coarser siliciclastic influxes, more plant material and no marine body fossils. Ichnofossils found were nondescript simple tubes. The gray shale facies probably represent higher oxygen levels, higher energy in the drowned distributary channel and probably lower salinity. Circulation was open to the sea at one time, but was subsequently cut off by delta switching. The marine muds were later filled in by possible lacustrian and or channel deposits of the Pounds due to shifting and progradation of the deltaic complex.

The gray shale facies are soft poorly fissile and have common carbonized impressions of plants. They are typically found at two stratigraphic horizons within the Drury: one near the upper part of the unit and the other near the base of the Drury (sometimes called the Gentry Coal). Rooted underclays with coal stringers and abundant plant fossils are found discontinuously within the gray shale facies. In Section 4, T.12S., R.4E., of the Creal Springs Quadrangle, the gray shale facies occurs below the Pounds, having numerous pieces of lycopod stems, leaves and pinnules with lycopod bark and various plant impressions. A similar example exists just below the Pounds in the

Eddyville Quadrangle (Sec. 1, T.10S., R.5E.). In Stonefort, a coal was found below the Pounds (in Sec. 3, T.12S., R.5E., Sec. 31, T.11S., R.5E.) and several other locations throughout the study area. Palynological analysis indicates that these discontinuous coals were all deposited at about the same time, and same environmental conditions, and that they all occur above the Gentry coal (personal communication R. Peppers, 1986). The Gentry coal occurs at a lower Drury horizon within the gray shale facies just above the Battery Rock Sandstone.

The gray shale facies in interpreted to be marsh and swamp areas on the lower delta plain, filling paleo-oxhoove and floodplain areas.

Fine grained, thin bedded, flaggy sandstone beds 1 to 3 feet thick, usually 10 foot benches exposed, yield a clean tightly cemented (silica) crossbedded quartz sandstone facies within the Drury. This facies is common in the Drury. A good example was observed in the Eddyville Quadrangle (NE 1/4, SE 1/4, SE 1/4, Sec. 6, T.11S., R.6E.). This fine grained facies is commonly associated with poorly laminated carbonaceous siltstones. The sandstones are planar, sometimes ripple marked, and crossbedded and may represent channel sheet sand splays associated with floodplain deposits. Bioturbation is low. When ichnofossils are found, they are usually Pelecypodichnus, which were most likely produced by fresh or brackish water carbonicoloid bivalves.

Another fine siliciclastic facies i the laminated siltstone facies. This facies is typically bioturbated having horizontal feeding burrows typical of marine deposit feeders. One example of this facies was found just west of Eddyville along a horse trail, crossing Hayes Creek. This facies is associated with the black shale facies laterally and the fine grained herring-bone crossbedded sandstone facies.

Exposures within Petes Cave, NE 1/4, NE 1/4, Section 2, T.12S., R.5E., show two distinct sandstones. The main cliff and roof of the cave or rock-shelter is a massive light gray sandstone with quartz pebbles. This sandstone is poorly sorted fine to coarse grained, sugary textured, Pounds Sandstone. It rests with an erosional contact on a light yellowish gray very fine grained cross bedded sandstone facies. The primary sedimentary feature of this sandstone is the herringbone crossbeds. The foreset beds dip in opposite directions, suggesting current reversals. This is typical of tidal channels or smaller tidal creeks. There is up to 15 feet of relief on the contact between the overlying Pounds and the fine grained herringbone facies of the Drury. This herringbone sandstone is interpreted as being tidally deposited. Besides the opposing direction of the foreset-dip direction and lateral equivalence to bioturbated siltstone facies and the marine black shale facies, no other evidence was found to support the tidal hypothesis.

No major channel sandstones were found within the Drury. It is thought that these channels occur in the Battery Rock and Pounds, and in places are intimately related to the Drury Member.

Pounds Sandstone Member

The Pounds, although thicker, is quite similar to the Battery Rock Sandstone. The reoccurrence of the same depositional environments that had produced the Battery Rock was also prevalent in the Pounds. The main element seen in the Pounds are distributary lag deposits, point bar and side or transverse bar deposits with associated floodplain and overbank splays.

The paleontology also reflects these environments of deposition. Fossils found are usually large vascular plant debris; lags of Lepidodendron and Calamites being the most common. Ichnofossils are rare because of poor preservation potential under such environmental conditions. However, occasionally a few behavioral imprints do get preserved. In the Eddyville Quadrangle near the bridge crossing over Bear Branch Creek (NW 1/4, NE 1/4, SW 1/4, Sec. 32, T.11S., R.5E.) the trace fossil Pelecypodichmus was observed. Only pieces of float were found containing the bivalve resting traces below the outcropof Pounds in the stream. However, the bivalve traces were preserved in a Pounds lithology. One sample that was collected yielded several elongate carbonicoloid-like Pelecypodichnus epireliefs. No other

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Fig. 6. Paleo channels through the study area

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ichnofossils were associated with the Pelecypodichnus nesting traces. The appearance of these molluscan traces within the Pounds does not hinder the distributary channel hypothesis of the Pounds in this area.

The Caseyville, in the study area, was mainly laid down on the uplands from the sub-Pennsylvanian valleys. In the Eddyville Quadrangle there is evidence for a deep paleovalley bisecting the quadrangle extending from the northeast corner to the southwest corner (Fig. 6). Also a pre-Pennsylvanian channel is thought to extend through the northwestern corner of the Creal Springs Quadrangle. These channels and related uplands greatly effected the deposition of the siliciclastics of the Caseyville in the study area. The marine elements found in the sandstones, siltstones and shales of the Caseyville seem to be confined to the paleo valley trend in the Eddyville Quadrangle.

Lower Abbott Lentils

The lower part of the Abbott Sandstone is composed of discontinuous lenticular sandstone bodies and laterally equivalent siltstones, very fine sandstone and shale facies. Some of these lenticular sandstone facies get up to 40 feet thick and are light brown to weathered deep golden brown, fine grained, well sorted quartz rich sandstones much like lower Caseyville Formation. Generally, clay weathered from feldspars in the matrix is more prevalent in the Abbott sandstones (Kosanke et al., 1960).

In the Eddyville Quadrangle (location 373) epsilon cross bedding was a striking primary sedimentary feature found in a broad laterally accreating lenticular sandstone body. Fossil logs of lycopods are common and occasional shale pebbles are also observed near the base or below such crossbedded facies. This particular locality probably represents a small point bar deposit of a distributary channel. A gray silty poorly laminated shale facies was also found in the lower Abbott of the Eddyville Quadrangle (location 471).

Plant fossils are common in this shale facies. No trace fossils were observed. This facies is thought to represent lateral floodplain deposits or marshy low areas laterally from the distributary channels on the lower delta plain.

Along a south flowing tributary to Lusk Creek (NW 1/4, NE 1/4, NW 1/4, Sec. 28, T.11S., R.4E.) in the Eddyville Quadrangle a few specimens of *Conostichus* sp. were collected. These cone-shaped traces are thought to be domicile impressions of burrowing sea anemonies (Chamberland, 1971). These marine ichnofossils were weathering out of thin bedded fine grained sandstone and siltstone facies occurring just above the Pounds Sandstone. This so far is the only occurrence of a marine sandstone in the lower Abbott Sandstone, in or outside of the area studied.

In the Stonefort Quadrangle a lower Abbott sandstone lentil has been found which contains abundant quartz pebbles and is more closely related lithologically to the Pounds Sandstone Member of the Caseyville (location 614 Stonefort). Most of the lower Abbott is probably non-marine distributary deltaic facies much like the lithofacies of the Pounds and Battery Rock of the Caseyville.

Middle Abbott Lentils and the "Olive Shale"

The middle portion of the Abbott Sandstone is composed of broadly discontinuous lenticular sandstone façies and also siltstone, shale and in some rare cases arenaceous limestone or calcareous sandstone facies. Above the middle Abbott sandstone lentils is the "Olive Shale." The Olive Shale is primarily composed of fine grained siliciclastic like shales and siltstones that are closely related to the underlying middle Abbott sandstones. Both the middle Abbott and "Olive Shale" were mainly deposited under marine conditions.

In a southeastward flowing stream located in the western half of Sec. 10, T.11S., R.6E., of the Eddyville Quadrangle there is a sandstone lentil forming an 8 foot ledge. *Zoophycos* was common within the lower part of this sandstone body. The sandstone facies is red to yellow-brown, fine to medium grained, coarse grained in places, with some granules present. Mica is common. The matrix is composed of moderate amounts of clay and liesegang banding is present. Primary sedimentary features are crossbedding and planar topsets. An average bearing taken on the foresets was estimated to be due south. Below the *Zoophycos* zone is a black shale facies about one foot thick containing abundant fossils of the inarticulate brachiopod *Orbiculoidea*. Below the *Orbiculoidia* bed is a dark gray shale with sulfur laminae and selenite crystals near the top of the shale. At the base of the dark gray shale is a rooted zone full of stigmarian rootlets.

This area is interpreted as being a fresh water swamp which developed into a shallow deltaic lake. The stigmarian zone at the base of this sequence provides evidence for the terrestrial swamp. However, subsidence was fast enough so as not to develop a coal. Instead, a possible fresh or brackish water lake formed and subsequently evaporated leaving sulfur hands and selenite crystals at the top of the deposit. Continued subsidence or sea level rise increased the salinity enough to harbor inarticulate brachiopods which eventually gave way to normal marine subtidal conditions allowing marine

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Fig. 7. Diagram of an unnamed ichnofossil

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deposit feeding organisms to seive through the organic rich sandstones. *Zoophycos* was not found in the Stonefort Quadrangle, possibly because this area was higher topographically. This higher elevation may have been related to the uplands that existed here during late Chesterian and late Morrowan time. Indications of marine zone stacking has been found along the proposed paleovalley extension through Eddyville, Waltersburg and Glendale Quadrangles (Devera, in preparation) (Fig. 6). A middle Abbott marine zone was also prevalent in the central portion of the Creal Springs Quadrangle. This was based on an actual limestone (black micritic with holomarine fauna) (see R. Jacobson). *Zoophycos* beds become more abundant westward and have been found in the middle Abbott of the Goreville, Makanda, and Carbondale Quadrangles.

In another south flowing ravine near McNally Cemetary (NE 1/4, NE 1/4 of Sec. 10, T.11s., R.6E.) more marine trace fossils were found in a thin bedded, fine grained facies laterally equivalent to the Zoophycos bed. An unnamed filter feeding organism left a domicile trace on the sole of the five grained sandstone beds (Fig. 7). A small crescent shaped opening is also found on the top of the beds. The organism probably situated itself into the prevailing current because all of the crescent shapes are facing the same direction (NE). Other ichnofossils found were Torrowangen, complex bifurcating burrows and another unknown repichnion. This facies probably represents a back water shallow tidal creek closely related to the Zoophycos bed both geographically and depositionally.

The "Olive shale" has a marker horizon that is intensely burrowed and can be traced from the Eddyville to the Stonefort and into the Creal Springs Quadrangle. The ichnofossil horizon occurs below the Murray Bluff lentil and is composed of Planolites, a simple tubular burrow that is 1/4 to 3/8 inches in diameter, horizontal and straight to wavy. Planolites is found in both shale and siltstone facies. In the shales the burrows are typically siltfilled or sandfilled and weather as full reliefs. In the Eddyville Quadrangle this burrowed zone was found in at least 6 locations (notes 486, 363, 499, 731, 732 and 733). In the Stonefort Quadrangle this horizon was observed in numerous localities (notes 560, 696, 702, 703, 704 and 742). In the Creal Springs the Planolites were also a very reliable marker. This is a distinctive local correlation tool that was very helpful in the upper parts of the "Olive shale."

The depositional setting was probably marine delta front shales, sands and siltstones. Episodic and slow rates of sedimentation probably existed which is evident from the profuse amount of bioturbation that is found in the upper parts of the "Olive shale." The deltaic lobe providing the finer-grained siliciclastics was probably the overlying Murray Bluff lentil.

In the Stonefort Quadrangle along Ogden Branch (loc. 647 and 648) the ichnofossils Pelecypodichnus Planolites and Cochlichnus were collected. This assemblage does not establish the salinity of the water at this location. These traces are found in a thin bedded laminated siltstone facies of the "Olive shale."

A poorly developed limestone was observed on the west side of Blackman Creek, at the mouth of the gully (600 feet east of the center of Sec. 34, T.10S., R.6E.) in the Eddyville Quadrangle. This unit also occurs in the "Olive shale" which is stratigraphically higher than the middle Abbott Zoophycos zone. The limestone is an impure reddish brown arenaceous packstone with many fossil fragments of pelmatozoans and articulate brachiopods.

The limestone appears to have been a near-shore high energy environment or tempestite deposit because of the taphonomic characteristics of the fauna. The fossils are abraded, disarticulated and fragmented which could have happened during transport along shore or during storm action. No organisms were found in life position.

Murray Bluff Sandstone Lentil and Associated Facies

The Murray Bluff Sandstone is a broadly lenticular siliciclastic body composed of coarse grained quartz sand with local well sorted fine to medium grained beds. The predominant sandstone facies is typically found as a massive bluff former with tabular to trough cross beds and occasional quartz granules. This sandstone is well exposed by the New Burnside Anticline in northwestern Eddyville and northeastern Stonefort Quadrangles. Other facies associated with the Murray Bluff lentil are thinly laminated very fine grained well sorted sandstones with current ripple marks, siltstones and few gray shales.

There are four main facies of the Murray Bluff. The first is a poorly sorted fine to coarse grained quartz sandstone with quartz granules and gray, red and purple shale clasts. This facies is laterally discontinuous and thin. It is interpreted as a distributary channel lag deposit. Ancient logs are also found in this facies which is usually associated with fining upward sequences (as seen in the Eddyville Quadrangle location 358).

The second facies is the thickest and most common lithofacies of the Murray Bluff Sandstone lentil. It is made up of fine to medium grained quartz sand that displays large to moderately sized crossbedding. This lateral accreation facies is interpreted as point bars and side channel bars of distributary streams. A location in the Stonefort Quadrangle (loc. 553) shows large scale epsilon crossbedding (second facies) with an underlying basal conglomerate (first facies) yielding a preserved lateral accreating channel fining upward sequence.

The third facies type of the Murray Bluff is a fine to very fine grained laminated and ripple marked lithofacies. This facies probably represents high energy episodic deposits in very shallow water environments like overbank splays or flood plain pools. Stratigraphically this fine grained facies is found laterally or superjacent to the cross bedded facies. The fourth facies is composed of siltstones and shales. Repichnion (crawing traces) have been found in the siltstones and shales. Land plant debris is also a common element in this facies. This fourth lithofacies probably represents a floodplain environment.

All four of these lithofacies correspond to subenvironments that typify a constructional distributary system. Therefore, the Murray Bluff lentil probably was a non-marine deltaic lobe of the lower delta plain which was preserved by a eustatic event or subsidence. Evidence that supports this interpretation of the environment of deposition for the Murray Bluff is three fold: 1) coals are few, thin and sporadic suggesting a highly constructive deltaic out building, not deltaic abandonment facies; 2) the four lithofacies all support a fresh water origin, no marine ichnofossils have been found in

Fig. 8. Stratigraphy

these facies (Fig. 8); 3) the Murray Bluff Sandstone lentil is sandwiched by marine siliciclastics of the "Olive shale" and overlying marine shales and siltstones of the upper Abbott. Nearly all of the marine ichnofossils found in the Abbott occur either below or above the Murray Bluff.

Above the Murray Bluff in the Stonefort Quadrangle

Along the Illinois Central Railroad tracks (NW 1/4, NW 1/4, Sec. 5, T.11S., R.5E.) in the Stonefort Quadrangle abundant trace fossils were found in outcrops above the Murray Bluff Sandstone lentil. Trace fossils were reported from this locality by Pfefferkorn (1971). In a coarsening upward shale, siltstone, and sandstone sequences abundant core like domicile traces of *Conostichus broadheadi* are the most abundant. Other ichnofossils associated with *Conostichus* are *Teichichnus*, *Asterosoma*, *Aulichnites*, *Phycodes*, *Planolites*, *Beaconichnus*, *Tasmanadia*, *Stellascolites* (?) and an unnamed trace fossil.

Fig. 9. Diagram of Conastichnos affinity from Chamberland, 1971

Conostichus broadheadi is characterized by a conical to subconical shape and duodecimal symetry seen on the knobby extension at the apex of the core (called a physa Fig. 9). This organism lived in mud rich organic detritus. It was probably a detrital filter feeder. Chamberland (1971) described the trace marker as a burrowing sea anemone possibly an Actinarian. Asterosoma was a sediment working trace suggested by its radial shape feeding pattern common to many Annelids in modern marine habitats. Teichichnus is composed of long horizontal burrows stacked vertical to the bedding resembling stacked U-shaped roof gutters. This trace also represent fodinichnia (feeding traces). Auliclinites is a crawling trace possibly produced by the parastolic muscle contractions of gastropods.

The increase of siliciclastic size up section along with the occurrence of a normal marine ichnofauna lead to the interpretation of an outer distributary bay that was subsequently filled by a distributary channel switch.

References and Plates and Figures to come later

BLR:Mpaleontol

MEMORANDUM

TO: COGEOMAP Thinkers
FROM: Joe Devera
DATE: March 2, 1987
SUBJECT: The goniatite find and their environment

Verification of Axinolobus, a lower Pennsylvanian goniatite, has been established for the Illinois Basin. The generic determination is based on distinct external morphologies and sutures recognized by Charlie Mason of Morehead State, Kentucky. This has been concurred by Mac Gordon of the USGS, and a comparative study that was conducted by Royal Mapes. Besides Axinolobus, the genera Gastrioceras and Wiedeyoceras have also been found in the Drury interval, near Eddyville. Species determinations have been hampered by the juvenile ontogenetic stages of most of these goniatites. However, the occurrence of Axinolobus is exciting because:

1) Its occurrence in the Illinois Basin establishes a greater geographic distribution for this excellent index fossil. This is the farthest east that Axinolobus has been reported. It has been found in Texas, Chisum Quarry Member of the McCully Formation in Oklahoma and near the top of Bloyd Formation in Arkansas.

2) A variety of palynomorphs (49 different species) were found in association with the marine fauna. This will be helpful in making terrestrial and marine biostratigraphic connections. Goniatites, nautiloids, bivalves, articulate and inarticulate brachiopods, conodonts and gastropods have been found at the surface exposure of the black shale and in the core number E4.

3) Another important observation about this marine shale is that it is transitional at top and bottom with a quartz pebble conglomerate sandstone. This presents a paradox, because high abundance of goniatite cephalopods in a dysaerobic environment such as this is typically indicative of deep water shales. However, one does not find poorly sorted quartz pebble conglomerate sandstones intertonguing with deep water pro-deltaic shales.

My best guess is that this shale was an estuary, a drowned distributary channel, that had normal salinity because of a choked distributary channel. This distributary was choked by a lot of organic matter (plant material) which lowered the O_2. The exact position of this shale was probably nearer to the sea than to the land. Circulation must have been open to the sea.

ANY SUGGESTIONS, COMMENTS, OR NEW IDEAS?

(Connected is a stratigraphic column and faunal list).

MOcogeoJAD

FIGURE 1

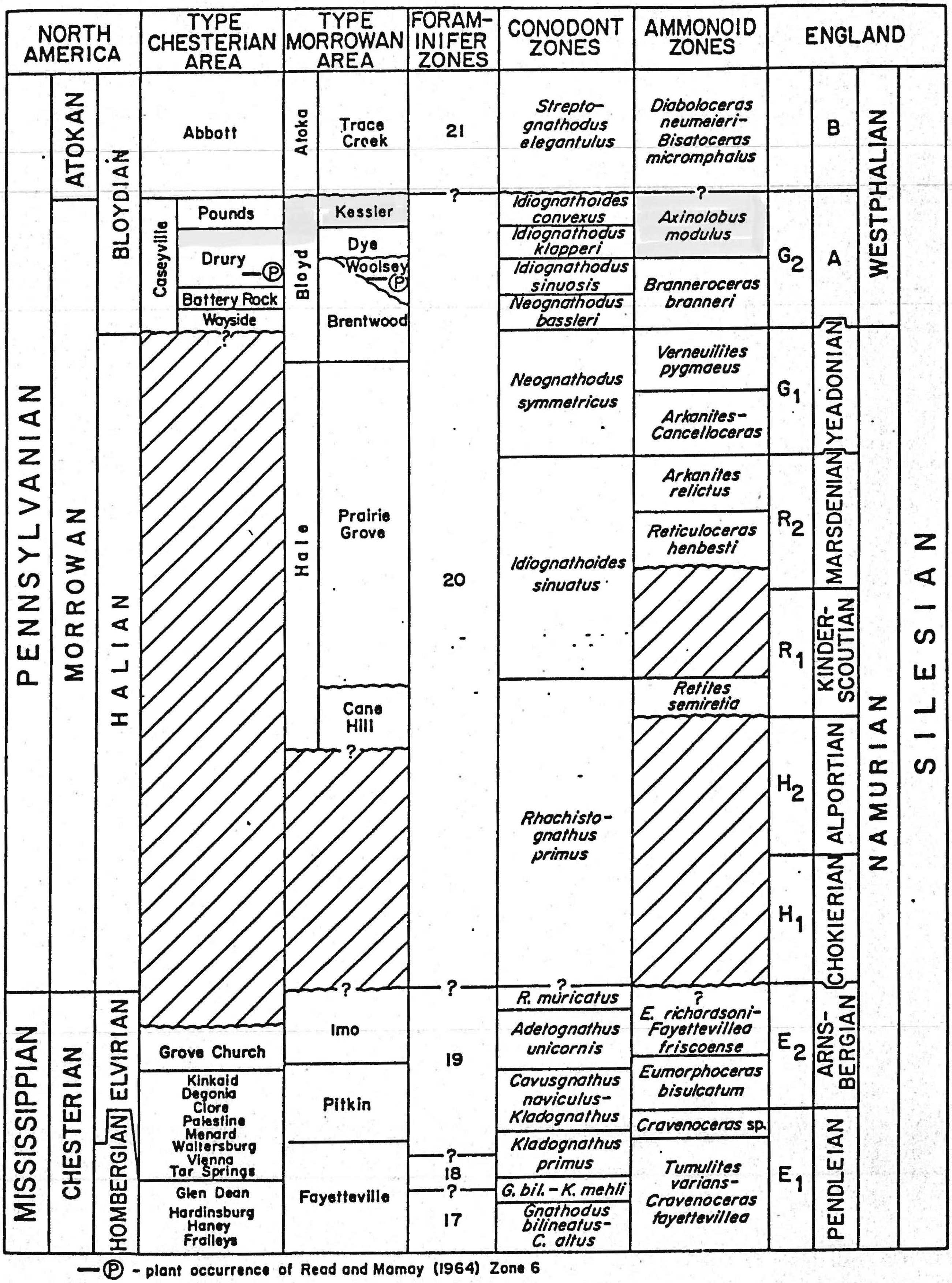


FIGURE 2. Correlation of type Chesterian and type Morrowan lithostratigraphic and biostratigraphic units in proximity to Mississippian-Pennsylvanian boundary and their standard European middle Carboniferous equivalents.

IX-ICC v. 2:369-376, p. 371

From: Manger and Sutherland, 1984

Maceration 3031

Deltoidospora subadnatoides (Bhardwaj) Ravn 1986
Punctatisporites flavus (Kosanke) Potonié and Kremp 1955
P. sp.
Calamospora hartungiana Schopf (in Schopf, Wilson, and Bentall 1944)
Gulisporites torpidus Playford 1964
Granulatisporites granularis Kosanke 1950
G. sp.
Waltzispora prisca (Kosanke) Sullivan 1964
Cyclogranisporites aureus (Loose) Potonié and Kremp 1955
Verrucosisporites sp.
Lophotriletes mosaicus Potonié and Kremp 1955
Apiculatasporites sp.
Pilosisporites echinatus (Knox) Ravn 1986
P. triquetrus (Smith and Butterworth) Ravn 1986
P. sp.
Raistrickia crocea Kosanke 1950
Foveosporites sp.
Convolutispora florida Hoffmeister, Staplin, and Malloy 1955
C. mellita Hoffmeister, Staplin, and Malloy 1955
Dictyotriletes bireticulatus (Ibrahim) Potonié and Kremp 1954
Ahrensisporites guerickei var. ornatus Neves 1961
Reticulatisporites sp.
Savitrisporites nux (Butterworth and Williams) Smith and Butterworth 1967
Crassispora Kosankei (Potonié and Kremp) Smith and Butterworth 1967
Simozonotriletes intortus (Waltz) Potonié and Kremp 1954
Densosporites annulatus (Loose) Smith and Butterworth 1967
D. sphaerotriangularis Kosanke 1950
D. triangularis Kosanke 1950
D. variabilis (Waltz) Potonié and Kremp 1956
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall 1944
L. noctuina Butterworth and Williams 1958
L. pellucida (Wicher) Schopf, Wilson, and Bentall 1944
L. subjuga Bhardwaj 1957
Cristatisporites connexus Potonié and Kremp 1955
C. indignabundus (Loose) Staplin and Jansonius 1964
Cirratriradites saturni (Ibrahim) Schopf, Wilson, and Bentall 1944
C. sp.
Kraeuselisporites ornatus (Neves) Owens, Mishell, and Marshall 1976
Cingulizonates cf. landesii (Staplin) Staplin and Jansonius 1964
Radiizonates striatus (Knox) Staplin and Jansonius 1964
Endosporites staplinii Gupta and Boozer 1969
E. zonalis (Loose) Knox 1958
Alatisporites pustulatus (Ibrahim) Ibrahim 1933
Laevigatosporites desmoinesensis (Wilson and Coe) Schopf, Wilson, and Bentall 1944
Vestispora magna (Butterworth and Williams) Spode (in Smith and Butterworth 1967)
Florinites visendus (Ibrahim) Schopf, Wilson, and Bentall 1944
F. sp.
Limitisporites sp.
Trihyphaecites triangulatus Peppers 1970

FIGURE 3

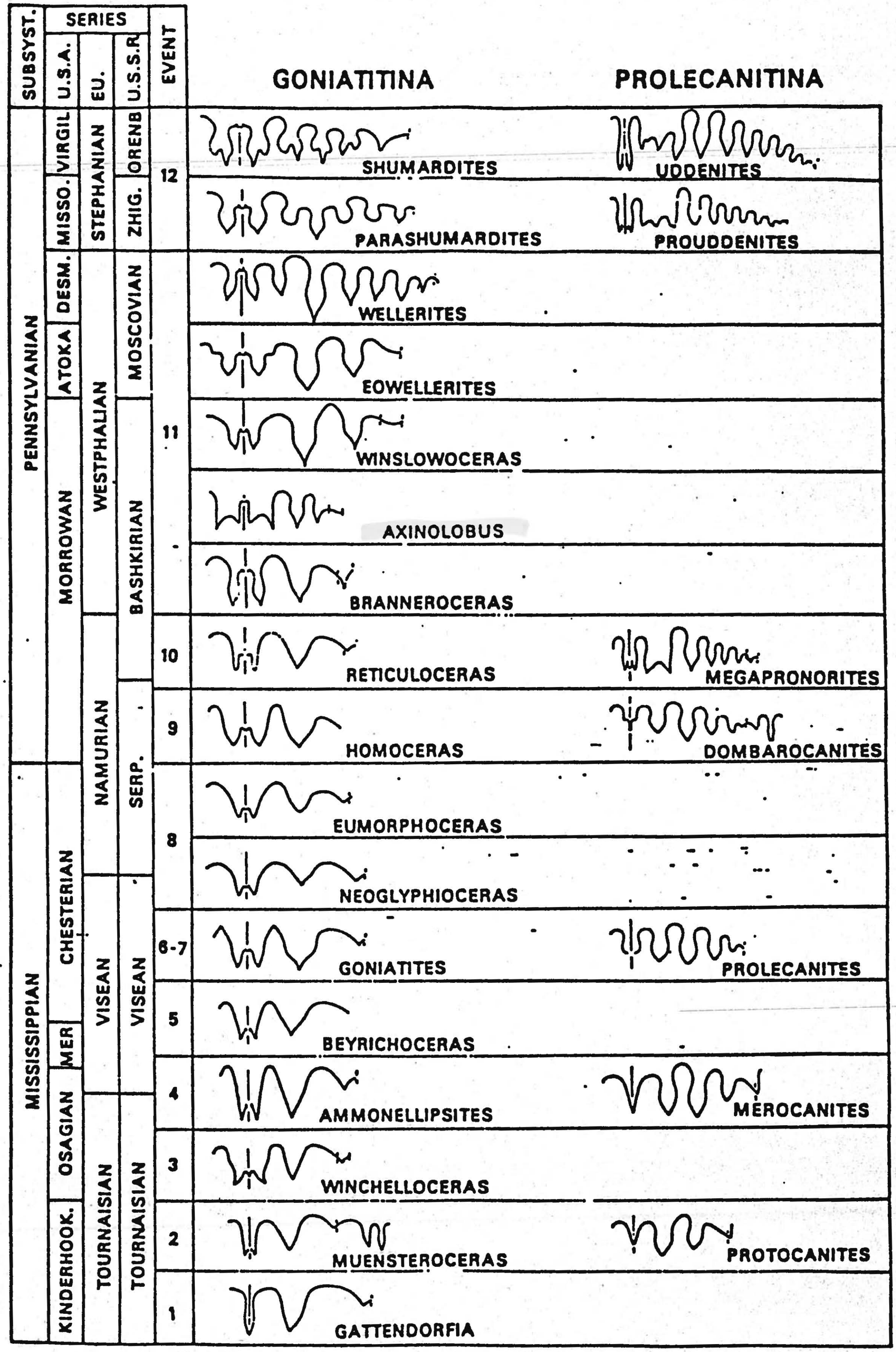


FIGURE 2. Sutural events in the evolution of Carboniferous ammonoids (including suborders Goniatitina and Prolecanitina); see text for explanation.

From: Ramsbottom and Saunders, 1984

MEMORANDUM

TO: COGEOMAPers
FROM: Joe Devera
DATE: May 27, 1986
SUBJECT: Biostratigraphy/E.O.D. of a segment of the "Drury" Interval

Last Wednesday (May 21) through Friday (May 23), Charlie Mason, Todd Stewart of Morehead State, Kentucky, and I collected approximately 350 fossils from the black shale below the Pounds Sandstone Member along Little Bear Branch. The fauna was dominantly molluscan, composed of amminoids and a few bivalves. Inarticulate and a couple of productid brachiopods were also obtained from this fauna. The amminoids comprise about 90% of the specimens found. Gastrioceras is the most common genus, having up to 5 different species represented. Axinolobus is a rare form. Only 4 partial specimens were recovered of this latter genus. Specific determinations of the genera will take place at the U.S. National Museum later this summer.

Biostratigraphy

Both genera Gastrioceras and Axinolobus are restricted to lower Pennsylvanian rocks. More importantly, Axinolobus has been found to occur in the Kessler Limestone Member of the Bloyd Shale and the upper part of the Witt Springs Formation in Arkansas (fig. 1). The genus Gastrioceras is widespread in the Upper Namurian and Westphalian of Europe, in Great Britain zones R2, G1, G2 and A, Belgium zones Wn1a to Wn3a (fig. 2).

Correlation with Arkansas, Texas and Kentucky, as well as Europe and Algeria, has been accomplished at the generic level. More detailed study of the species should yield finer resolution of relative time.

Environment of Deposition

The presence of a dominant amminoid fauna along with the absence of nautiloids suggests deeper water conditions. Anaerobic to disaerobic conditions are displayed within the black shale by an increasing faunal diversity upward and the change in preservation of shell material. In the lower portion of the shale the cephalopods are replaced by pyrite; upward no pyrite is found, only impressions and casts of the organisms. Near the top, the shell material is composed of calcite.

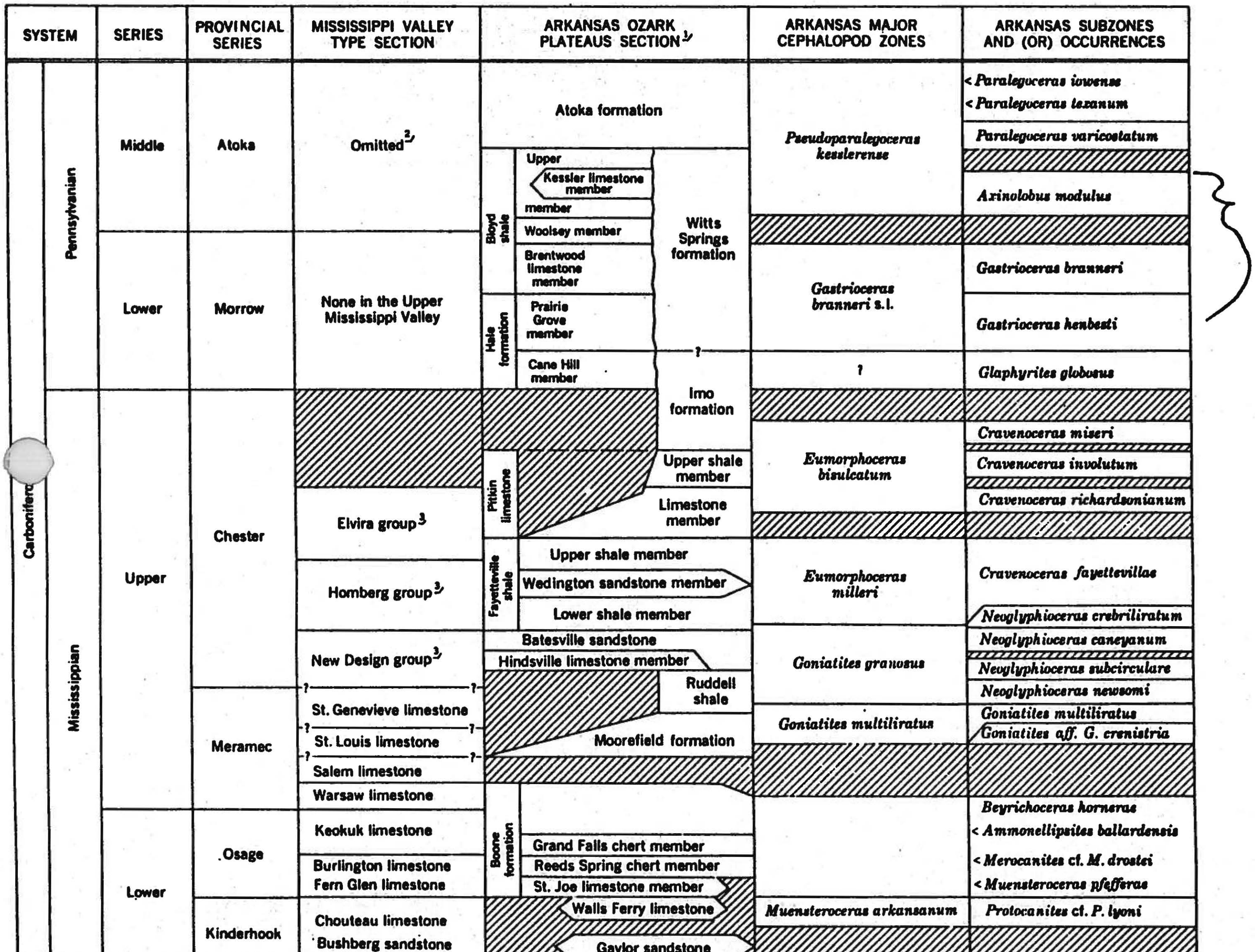
Proposed Revision of Drill Hole

I am suggesting that we drop one of our weakest drill site locations and substitute drill hole # E4 (Center Sec. 32-11S-6E). Reasons for substitution:

1) Better lithologic definition of the upper and lower contacts of the black shale.
2) Abundance of amminoids in this shale.
3) Biostratigraphic importance of the zone.
4) Reynoldsburg Coal.
5) Possible Gentry Coal.

MO-JAD-527

CEPHALOPOD FAUNAS OF THE MISSISSIPPIAN AND PENNSYLVANIAN ROCKS IN ARKANSAS



1/ Named rock units in Washington County shown on left side of column

2/ The Pennsylvanian system is omitted because the type section is not in the Mississippi Valley

3/ Of Weller, 1939

figure #1

TABLE 11.—*Correlation of the Carboniferous formations and goniatite zones of the Ozark Plateaus and Ouachita Mountains of Arkansas with the goneatite zones and stages of northwestern Europe*

NORTHWEST EUROPE						ARKANSAS						
Stage			Goniatite zones: British	German	Characteristic species		Stratigraphic sequences: Ozark plateaus	Ouachita Mountains	Provincial Series	Series	System	
Upper Carboniferous	Westphalian	C	A	ε	*Anthracoceras aegiranum*	*Pseudoparalegoceras kesslerense*	Atoka formation	Atoka formation	Atoka	Middle	Pennsylvanian	Carboniferous
		B	G2	δ	*Gastrioceras listeri*							
		A		V γ β		?	Bloyd shale	Witts Springs formation	Johns Valley shale	Morrow	Lower	
	Namurian	Upper	G1	α	*Gastrioceras cancellatum*	*Gastrioceras branneri s.l.*	Hale formation					
		Middle	R2	IV δ γ	*Reticuloceras bilinguae, superbilinguae*	?		?				
			R1	β α	*Reticuloceras reticulatum, inconstans*			Imo formation				
		Lower	H		*Homoceras beyrichianum*					Chester	Upper	Mississippian
			E2		*Eumorphoceras bisulcatum*	*Eumorphoceras bisulcatum*	Pitkin limestone					
			E1		*Eumorphoceras pseudobilingue*	*Eumorphoceras milleri*	Fayetteville shale	? ? Erratics in Johns Valley shale ? ? ?				
Lower Carboniferous	Viséan	Upper	P2	III δ γ	*Goniatites granosus*	*Goniatites granosus*	Batesville sandstone	? ? Erratics in Johns Valley shale ? ? ?				
							Ruddell shale		?			
			P1b-d	IIIβ	*Goniatites sphaericostriatus*	*Goniatites multiliratus*	Moorefield formation		Meramec			
			P1a	IIIα	*Goniatites crenistria*		?					
		Middle	B2		*Beyrichoceras delicatum*	?						
			B1		*Beyrichoceras hodderense*	?*Beyrichoceras hornerae*	Boone formation		? Osage	Lower		
		Lower	S1	IIδ	*Ammonellipsites carinatus*	*Ammonellipsites ballardensis*						
			C2	IIγ	*Ammonellipsites kochi*	*Merocanites cf. M. drostei*						
				IIβ	*Ammonellipsites plicatilis*	*Muensteroceras pfefferae*	?					
	Tournaisian		C1	IIα	*Ammonellipsites princeps*	*Muensteroceras arkansanum*	Walls Ferry limestone		Kinder-hook			
			Z2	Iβ	*Protocanites geigenensis*							
			Z1	Iα	*Protocanites lyoni*		Gaylor sandstone					

fis #2