STRATIGRAPHY and DEPOSITIONAL HISTORY of the CHEROKEE GROUP · SOUTH-CENTRAL IOWA

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Geological Society of Iowa

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SOUTH-CENTRAL IOWA

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GEOLOGIC AND STRATIGRAPHIC SETTING

Pennsylvanian-age rocks underlie approximately 20,000 square miles or about a third of Iowa and reach a maximum total thickness of 1600 feet in the southwestern part of the state. The Pennsylvanian sediments in Iowa were deposited in two major structural basins (Fig. 1). The Cherokee Group makes up the base of the Pennsylvanian sequence in the Forest City Basin of southern and southwestern Iowa (Ravn et al., 1984). In eastern Iowa the lowermost Pennsylvanian consists of an outlier of the Illinois Basin which has been assigned to the Caseyville Formation (Fitzgerald, 1977). The chart in Figure 2 shows the stratigraphic succession for the Pennsylvanian strata in Iowa. The positions of significant coal seams are also indicated.

The Cherokee Group averages approximately 500 feet thick across south-central Iowa, although it reaches a maximum thickness of 755 feet in southwestern Iowa near the center of the Forest City Basin (Ravn et al., 1984). The Pennsylvanian rocks dip gently to the southwest toward the center of the basin. Consequently, surface exposures become younger downdip toward the southwest (Fig. 3).

Cherokee Group strata are Atokan and Desmoinesian in age, but the Caseyville Formation is assigned to the older Morrowan Series (Fig. 2). Morrowan-age strata have not yet been identified underlying the Cherokee strata within the Forest City Basin (Ravn, 1986; Ravn et al., 1984). As previously noted, over most of its area the Cherokee Group forms the basal unit of the Pennsylvanian. However, a shale recovered from the basal Pennsylvanian in a drill core from Davis County, Iowa, produced an assemblage of miospores that was considered intermediate in age between the Morrowan assemblages from eastern Iowa and the miospores recovered from the Kilbourn Coal. Ravn (1986) considered the assemblage to be lower Atokan and speculated that it may represent a localized early Pennsylvanian-age unit, which was deposited in a depression on the underlying Mississippian. Ravn (1986) concluded from this that nearly all of the Lower and Middle Pennsylvanian are present in Iowa.

BACKGROUND OF STRATIGRAPHIC NOMENCLATURE

Historically, stratigraphic designations within the Cherokee Group were limited to informal designations of Upper Cherokee and Lower Cherokee and names applied to regionally resistant rock units. Unpublished work by L. M. Cline during the 1930's and an unpublished dissertation by Stookey (1935) were the significant attempts to establish stratigraphic subdivisions within the Cherokee Group. Stookey (1935) divided the Cherokee Group at the base of the Whitebreast Coal into two formations. The upper unit, named the Lucas Formation, was further subdivided into three members, and the lower unit, named the Wapello Formation, was divided into eight members. Cline and Stookey continued their collaboration on the Des Moines Supergroup into the 1940's and proposed group, formation, and member names based on extensive outcrop studies in Iowa. However, the work was not published and the proposed nomenclature was never adopted. More recent work by the coal project group at the Iowa Geological Survey during the 1970's showed that, although Cline and Stookey's work are a valuable source of information, some of their subdivisions of the Cherokee Group cannot be retained.

Gleim (1955) attempted to apply the stratigraphic subdivisions, Krebs and Cabaniss groups as proposed by Searight et al (1953) in

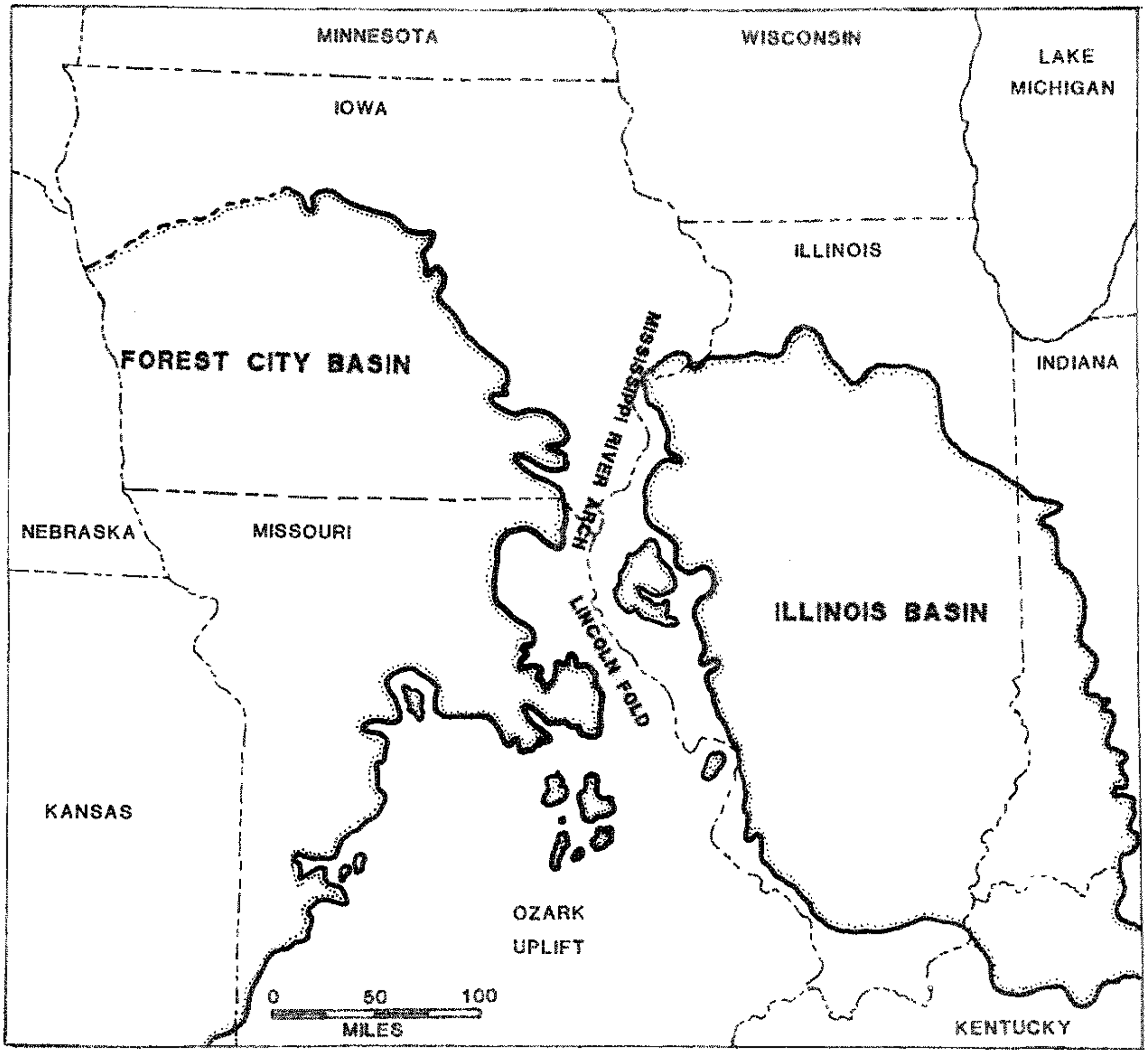

Figure 1. Major geological structures of the Midcontinent with limits of Pennsylvanian strata. Most Pennsylvanian in Iowa lies within the Forest City Basin, however a small outlier of the Illinois Basin is found in eastern Iowa.

Missouri, to the Cherokee Group strata in southeastern Iowa. However, the designation Cherokee Group returned to favor and continues to be utilized in Iowa.

A systematic coring program was conducted by the Iowa Geological Survey (now the Geological Survey Bureau, Iowa Department of Natural Resources) from 1974 to 1979 to determine the stratigraphy and depositional history of the Cherokee Group. By 1979, core holes were completed at 85 locations in southeastern and south-central Iowa. Extensive lithologic and biostratigraphic analyses were used to correlate between cores. The palynology of the coals was found to be the most useful means of correlating coals between cores. Analysis of palynomorphs from coals recovered from outcrops and mines has also proven to be an effective means of correlating these coals to intervals in the cores. Ravn (1979) described the

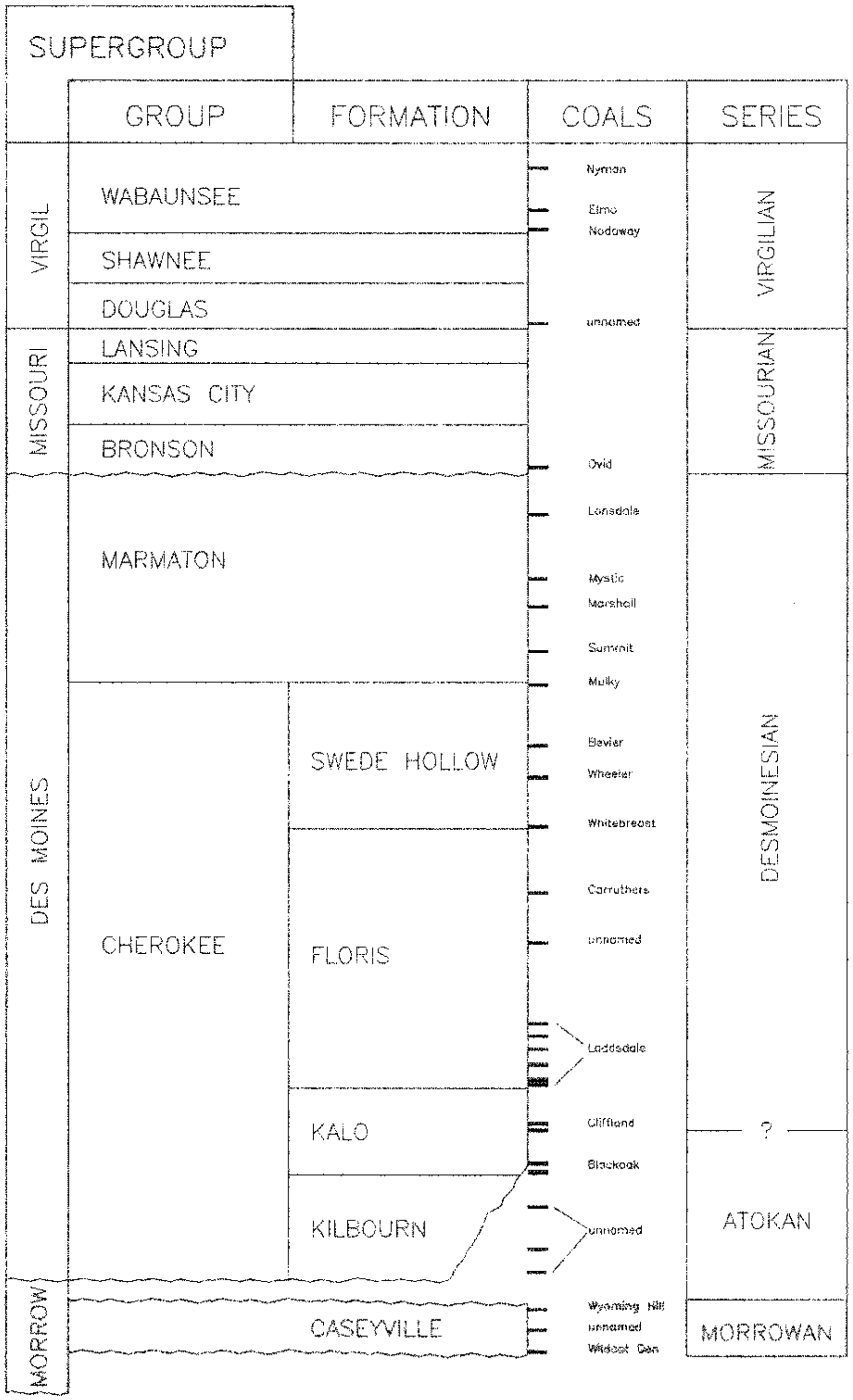

Figure 2. Stratigraphy of the Pennsylvanian System in Iowa (Ravn, 1986). Major unconformities exist between the base of the Cherokee and underlying Mississippian strata (not shown here) and between the Des Moines and Missouri supergroups. The Morrow Supergroup, although known to be older, does not occur below the Des Moines Supergroup. Instead it occurs as an outlier of Illinois Basin strata to the east (see Fig. 3).

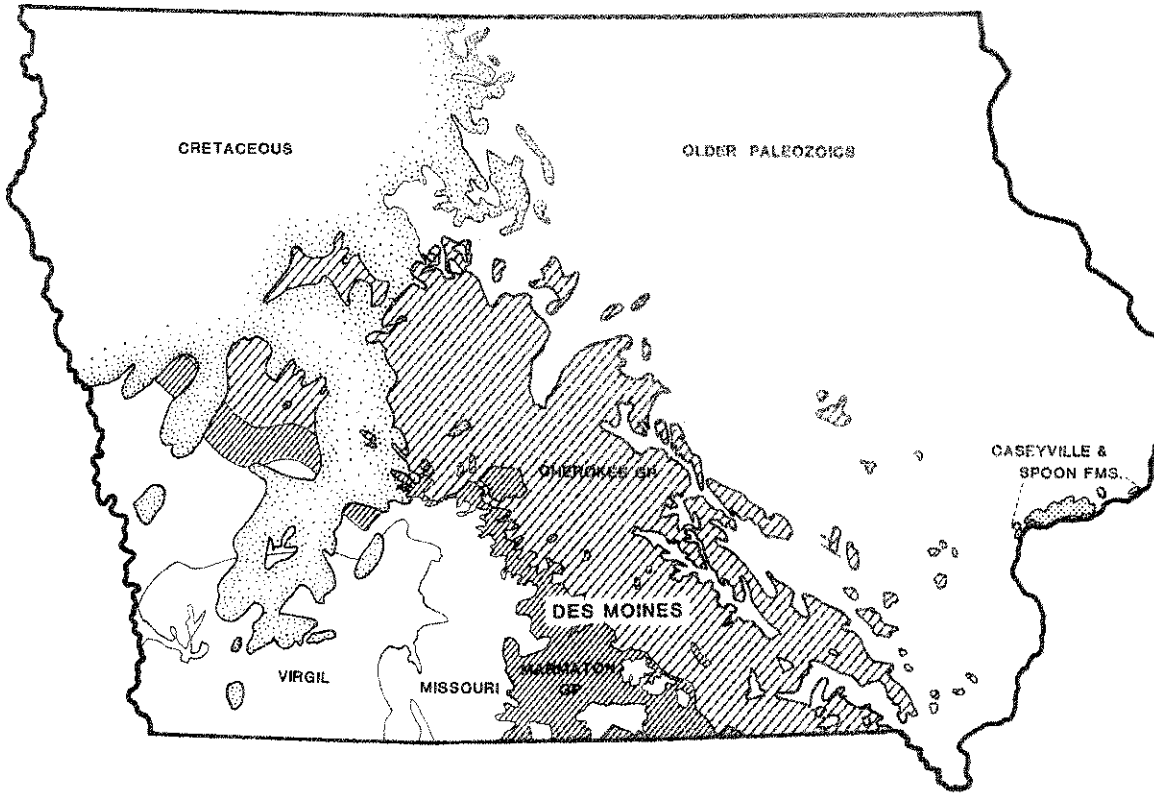

Figure 3. Pre-Pleistocene subcrop map. Note outlier of Caseyville and Spoon strata in eastern Iowa.

techniques used in palynological study and described the palynology of a coal recovered in an IGS Coal Resource Program core in detail. Ravn (1986) established a palynostratigraphic zonation for the Cherokee Group that can be utilized to establish correlations between coal beds in Iowa. The currently accepted, formal subdivision of the Cherokee Group in Iowa relies heavily upon this zonation.

A paper which appears later in this guidebook discusses the palynological zonation of the Cherokee Group in Iowa.

STRATIGRAPHY

The Cherokee Group in Iowa is subdivided into four formations (Ravn et al., 1984), which in ascending order include, the Kilbourn, Kalo, Floris, and Swede Hollow (Fig. 2). Each formation represents a major episode of deposition and is a product of a distinct depositional regime (Fig. 4).

Kilbourn Formation

The Kilbourn Formation is the basal unit of the Cherokee Group and is Atokan in age (Fig. 2). It is separated from the underlying Mississippian carbonates by a major unconformity and is locally characterized by a thick residual soil. Elsewhere, a conglomerate composed of clasts of the underlying Mississippian rock marks the contact.

The Kilbourn Formation filled topographic depressions on the weathered Mississippian surface (Fig. 5). Gradual marine transgression led to development of numerous localized environments in paleovalleys, resulting in a wide variety of sediment types (Fig. 6). The rise in local base levels created fluvial depositional systems and developed localized swamps

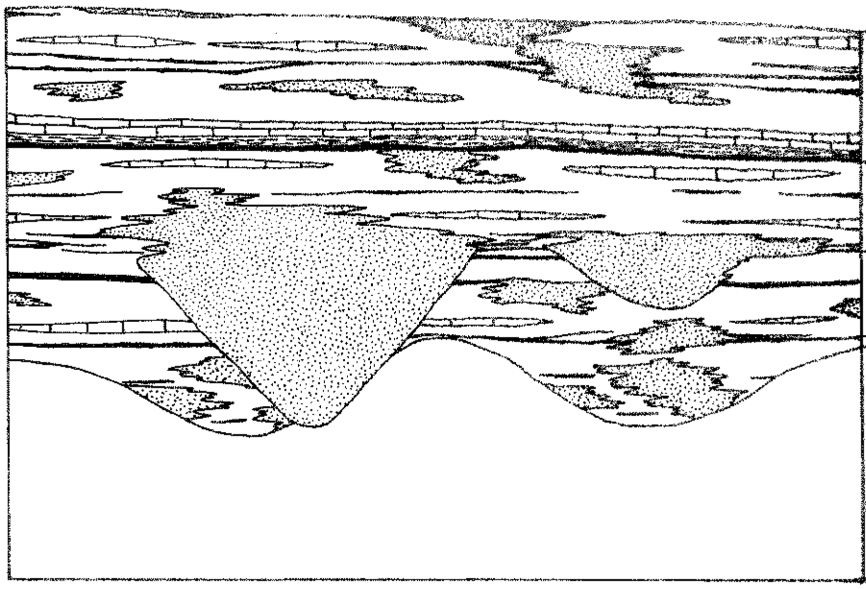

Figure 4. Schematic cross-section of the Cherokee Group in Iowa comparing depositional regimes. The Kilbourn Formation filled in irregularities on the Mississippian surface. The Kalo Formation produced two widespread, though highly variable coal seams. The Floris Formation began as a single episode of deltaic deposition, and evolved into a period of more marine influenced deposition which was punctuated by period of major channel erosion and infilling. The Swede Hollow began with a widespread marine transgression which produced one of the most widely traceable lithologic sequences in the Midcontinent region then progressed through two or more episodes of widespread peat deposition in a fluvial-deltaic environment, and concluded with the beginning of another eustatic cycle.

producing the thin, discontinuous coals which characterize the Kilbourn Formation. Marginal marine deposits developed along valleys including bioturbated sandstones, and lenticularly interbedded sandstone, siltstone, and shale. Thick shale sequences, probably prodeltaic in origin, are common. Fully marine deposition apparently occurred only along former valley axes during maximum transgression. Marine strata include dark shales and skeletal calcilutites with occasional thin zones of phosphate nodules (Ravn et al., 1984).

The coals within the Kilbourn Formation are correlated with the Tarter and Manley coals of northwestern Illinois and the Reynoldsburg Coal of southeastern Illinois (Fig. 7) on the basis of palynologic comparisons (Ravn, 1986).

Kalo Formation

The Kalo Formation consists of a complex system of deltaic deposits which are characterized by shifting sites of deposition and associated differential compaction. The resultant series of delta lobes are very complex, both laterally and vertically, and obscure the uniformity that might be expected from a regional rise in sea level (Ravn, 1986). The block diagram in Figure 8 shows some aspects of the environment in which the Kalo Formation was deposited.

The base of the Kalo Formation is marked by the Blackoak Coal (Fig. 2) which is the oldest widely traceable horizon within the Cherokee Group. The coal, itself, is highly variable in thickness and quality, and locally is split into two or more beds separated by up to 15 feet of shale (Gregory, 1982). The Blackoak Coal originated from peat which probably was deposited as a result of a regional rise in sea level over the relatively low relief surface created by deposition of the Kilbourn Formation. Continued gradual rise in sea level drowned the peat swamps and

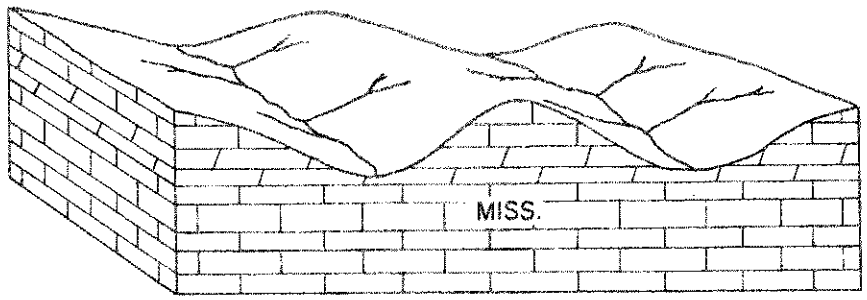

Figure 5. Deeply eroded Mississippian surface prior to the beginning of Pennsylvanian deposition.

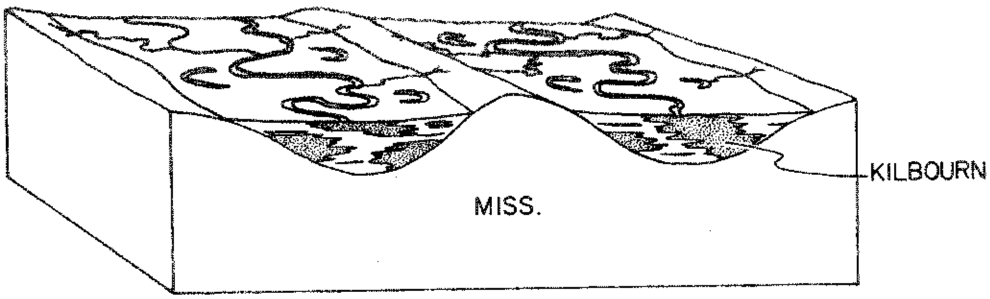

Figure 6. Deposition of Kilbourn Formation. Deposition occurred along paleo-valleys so strata are irregular and discontinuous.

established vast fluvial-deltaic systems. Finer-grained clastic sediments dominate in the Kalo Formation, in contrast to the coarser channel-filling sandstones that characterize the underlying Kilbourn Formation and overlying Floris Formation. Typically, the coal is overlain by one or more coarsening-upward sequences of interbedded shale, siltstone, and sandstone. The lack of coarser-grained lithologies is consistent with a gradual, widespread rise in sea level. Localized areas of marine deposition produced argillaceous or arenaceous skeletal calcilutites. Marine lithologies generally become more common to the west and southwest.

The Cliffland Coal is the upper named member of the Kalo Formation. Like the Blackoak, the Cliffland is very widespread, but somewhat more variable in character (Fig. 8). Deposition of the Cliffland Coal was probably the result of a second region-wide transgression which repeats many of the patterns of deposition associated with the Blackoak Coal (Gregory, 1982).

The Blackoak Coal is definitively correlated with the Pope Creek Coal of northwestern Illinois and the Willis Coal of southeastern Illinois on the basis of their palynology (Fig. 7). This relationship suggests a correlation between the Cliffland Coal and the Rock Island (No. 1) Coal of northwestern Illinois, however, the relationship is not clearly indicated by the miospore assemblages (Ravn, 1986).

Floris Formation

The Floris Formation represents a shift from sedimentation largely dominated by nonmarine fluvial and deltaic processes to sedimentation more influenced by lagoonal and marine processes. Small-scale tectonism is probably in part responsible for the complex lateral relationships seen within the Floris Formation.

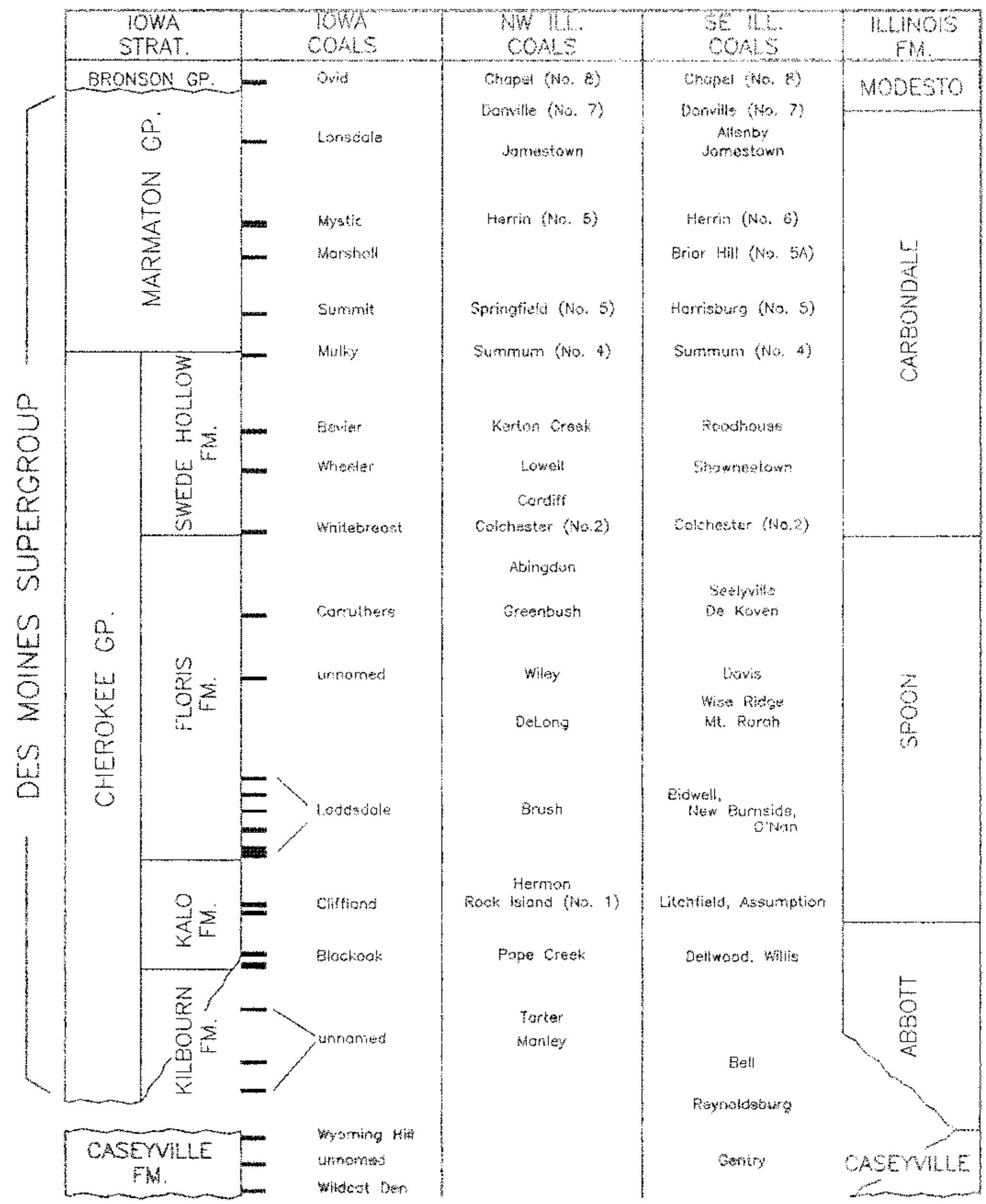

Figure 7. Correlation chart showing Illinois and Iowa coals (after Ravn, 1986).

Particularly striking are the thick, multistoried channel-filling sandstones such as those exposed at Lake Red Rock and near Cliffland, Iowa. These sandstone bodies appear to originate in the upper part of the Floris Formation and fill channels that cut well into the underlying strata, locally reaching the Mississippian carbonates. The block diagram in Figure 9 illustrates some of the complexity of the Floris Formation and the depositional environment of the upper portion of the Floris.

The base of the Floris Formation is marked by the Laddsdale Coal (Fig. 2). The Laddsdale consists of one or more closely related coal beds which originated from a single depositional event. The coal beds vary greatly in thickness and are

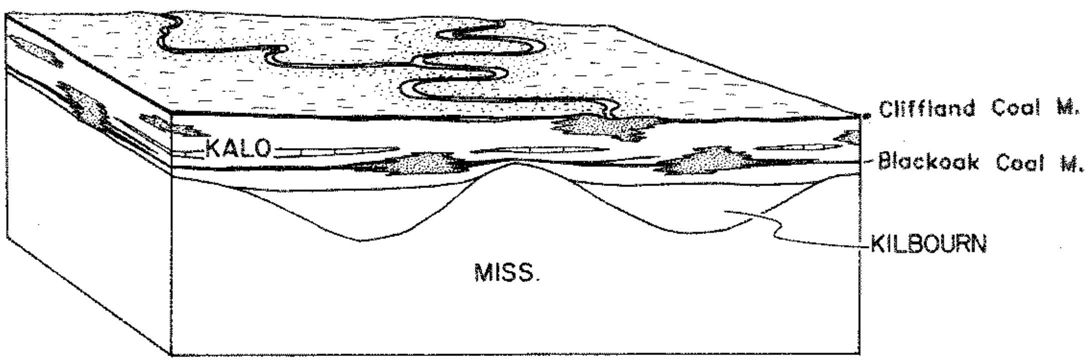

Figure 8. Deposition of the Kalo Formation. The Blackoak and Cliffland coals are the oldest widespread coals in the Forest City Basin of Iowa.

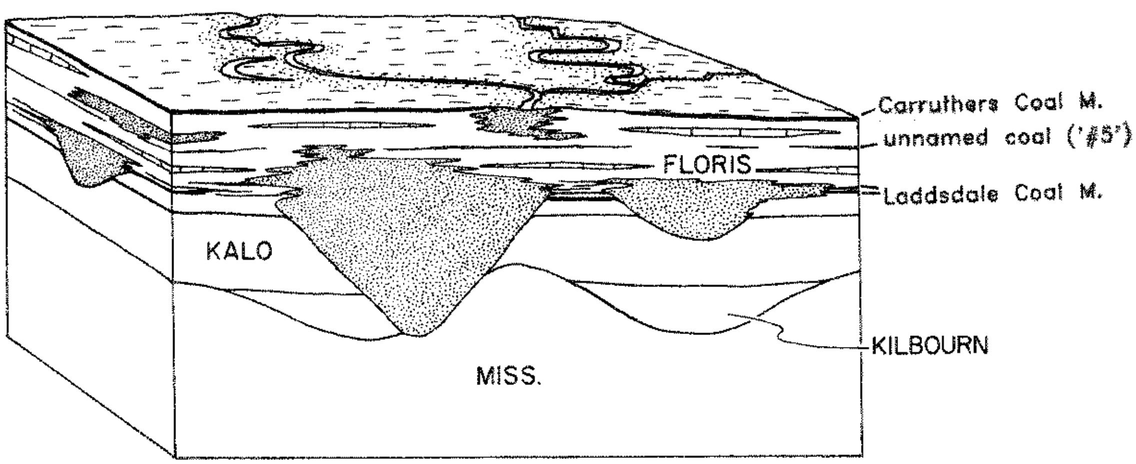

Figure 9. Deposition of the Floris Formation. The coals are discontinuous and irregular. Discontinuous limestones indicate localized marine environments. Thick channel sandstones may be the product of reactivated tectonic activity.

split by wedges of dominantly clastic sediment introduced by periodic inundation of the swamp. As many as six coal beds have been identified as Laddsdale in the subsurface, although several of these were present only as carbonaceous streaks. These coals cannot be distinguished on the basis of their palynology. Thin, impure lenses of fossiliferous limestone are found locally overlying one or more of the coal beds and probably represent deposition in interdistributary bays. These limestones are particularly common in Wapello and Davis counties and have previously been correlated with the Seville Limestone of Illinois (Landis and Van Eck, 1965), however, this correlation is not supported by recent work (Ravn et al., 1984).

Precise correlations with coals in Illinois are not possible because of the complexity of the strata, but the Laddsdale Coal is approximately correlated with the Brush Coal of northwestern Illinois, and the Murphysboro and New Burnside coals of southeastern Illinois. A possible correlation with the DeLong Coal of Illinois is also suggested (Fig. 7; Ravn, 1986).

A thin palynologically distinct coal occurs above the Laddsdale Coal in the Floris Formation. It is persistent across much of southeastern and south-central Iowa in the subsurface, but surface exposures have not been located. Therefore, no name was proposed for it (Ravn et al., 1984). Occasionally, the coal is split into two or more beds which cannot be distinguished on the basis of palynology. Like the Laddsdale Coal, they are assumed to represent a single episode of peat deposition which was split by wedges of clastic sediment. The interval between the unnamed coal beds and the overlying Carruthers Coal Member commonly consists of shale or silty shale with lenses of fossil debris, bioturbated zones, and scattered, intact brachiopods. Locally, thin zones of phosphate nodules are found immediately above the coal beds. This interval usually includes two thin or lenticular sparsely fossiliferous limestones. The upper bed is typically weathered. Either one or both of these limestones had been tentatively correlated with the Seahorne Limestone of Illinois (Landis and Van Eck, 1965), but this correlation is now considered to be inappropriate (Ravn et al.,1984). The unnamed coal in the Floris Formation correlates with the Wiley Coal of northwestern Illinois on the basis of the miospore assemblages (Fig. 7; Ravn, 1986).

The Carruthers Coal is a thin, persistent coal seam which is variable in thickness and quality (Fig. 9). It is typically overlain by marginal marine to marine shales and limestones. Lingulid brachiopods are commonly found in the shale immediately overlying the coal and a thin shale bed with abundant phosphate nodules is commonly found five to seven feet above the coal (Ravn et al., 1984). This sequence suggests gradual inundation in marginal marine to marine environments with little vertical water circulation. Swade (1985) suggested that the marginal marine to marine strata overlying the unnamed coal and the Carruthers Coal were precursors to the upper Desmoinesian eustatic cyclothems. The marine to marginal marine strata are followed by a return to peat deposition that produced a widespread coal, represented in Iowa as only a streak.

The Carruthers Coal is correlated with the Greenbush and DeKoven coals of Illinois (Fig. 7) and the streak which appears above the Carruthers is correlated with the Abingdon Coal of northwestern Illinois (Ravn, 1986). Previously, the coal now identified as Carruthers in Iowa was named Wiley on the basis of lithologic correlation of the underlying limestone with the Seahorne Limestone, which underlies the Wiley Coal in Illinois (Landis and Van Eck, 1965). The name Wiley was dropped when palynological analysis showed that this correlation was incorrect (Ravn et al., 1984).

Swede Hollow Formation

The Swede Hollow is the uppermost formation within the Cherokee Group. The strata which comprise the Swede Hollow Formation can be attributed to two distinct depositional regimes (Fig. 10). The lower part of the formation (Whitebreast Coal, Oakley Shale, and Ardmore Limestone) was deposited by a major cycle of marine transgression and regression. This interval can be traced across the Midcontinent from Oklahoma to Iowa, and across the Illinois Basin into Indiana (Swade, 1985). The upper portion of the Swede Hollow Formation, which is comprised of the Wheeler and Bevier coals and associated strata, was deposited by two cycles of deltaic progradation and abandonment, and is similar to older Cherokee Group strata (Fig. 10).

Whitebreast Coal

The Whitebreast Coal, which marks the base of the Swede Hollow Formation, is very widespread and can be traced over much of the Midcontinent region. It is correlated with the Colchester (No. 2) Coal of Illinois (Fig. 7) and the Croweburg Coal in Kansas and Missouri (Ravn et al.,1984; Ravn, 1986; Swade, 1985). The Whitebreast Coal is also very uniform in thickness across south-central Iowa, ranging from one foot to 1.6 feet (Ravn et al., 1984). The coal overlies a rooted mudstone (part of the Floris Formation) and records the earliest phase of transgression when the rising local water table permitted the growth of marginal swamps (Fig. 11). The extensive coals of the Upper Desmoinesian originated from diachronous belts of peat deposition which moved outward from the basin center as the water deepened. The miospore assemblages contained in widely separated samples of the Whitebreast Coal are nearly identical, further indicating the widespread nature and uniformity of the depositional environment. Peat deposition ceased with inundation of the swamp by marine water and the shift to fully marine environments of deposition (Swade, 1985;

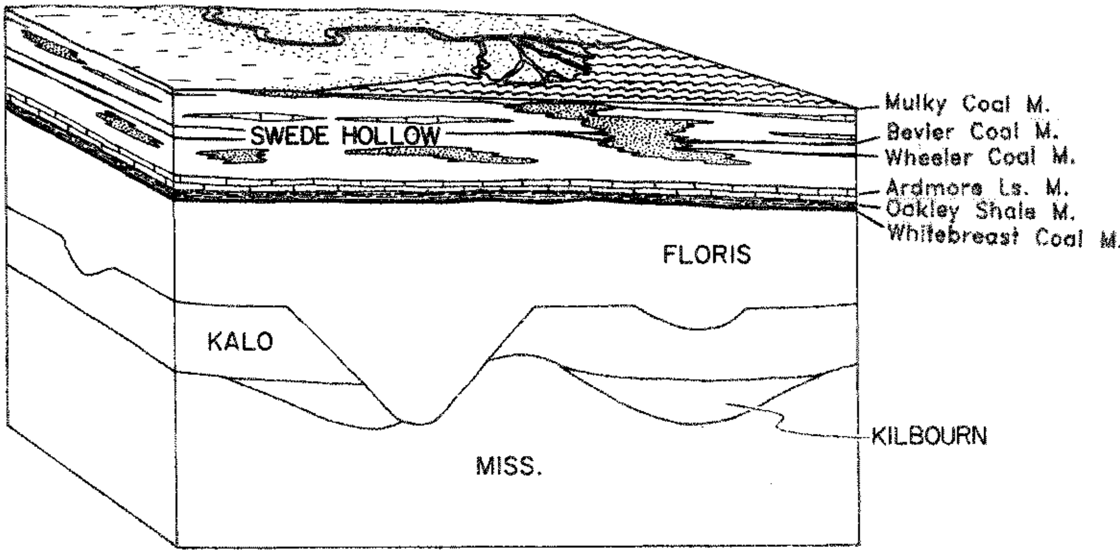

Figure 10. Deposition of the Swede Hollow Formation. The lower portion of the formation is extremely widespread and uniform in character. The upper portion more closely resembles older Cherokee Group strata.

Ravn et al., 1984).

Oakley Shale

The black, fissile, phosphatic Oakley Shale overlies the Whitebreast Coal (Fig. 11). Along the eastern margin of the Forest City Basin the Oakley Shale in most cases directly overlies the coal, although impure, fossiliferous limestone nodules have been observed locally at the contact between the coal and shale. Studies of drill cores obtained west of the outcrop area have shown that the black, phosphatic shale is separated from the coal by plant fossil-bearing gray shale and siltstone. The separation has been observed to increase westward and reaches 22 feet in thickness. The Oakley Shale is interpreted to represent the maximum transgressive (deepest water) phase of the depositional cycle. Transitional deposits (i.e. the middle limestone) between the initial stages of transgression (peat deposition) and maximum transgression (phosphatic, black shale) are usually absent in the Swede Hollow Formation. Heckel (1977) attributed the absence of a well developed middle limestone to rates of transgression which were too rapid to permit the establishment of carbonate-producing algae. Bottom conditions on the widespread peat may have also inhibited either algal growth or preservation of their skeletal remains (Swade, 1985). The black, phosphatic facies developed under anoxic sea floor conditions which developed when vertical water circulation was restricted. The phosphate was supplied by "up-welling" from deeper, colder ocean water (Heckel, 1977), presumably near the center of the Forest City Basin . The wedge of clastic sediment which appears and becomes thicker toward the west may represent an episode of deltaic progradation.

The Oakley Shale, like the Whitebreast Coal, represents a very widespread depositional regime. It is correlated with the Mecca Quarry Shale of Illinois and Indiana, and an as yet unnamed shale above the Croweburg Coal in Kansas and Missouri (Ravn et al., 1984).

Ardmore Limestone

The Ardmore Limestone is also a very widespread rock unit. It consists of two or more thin limestone beds separated by shale and represents the regressive portion of the eustatic transgressive-regressive cycle. The lower bed of

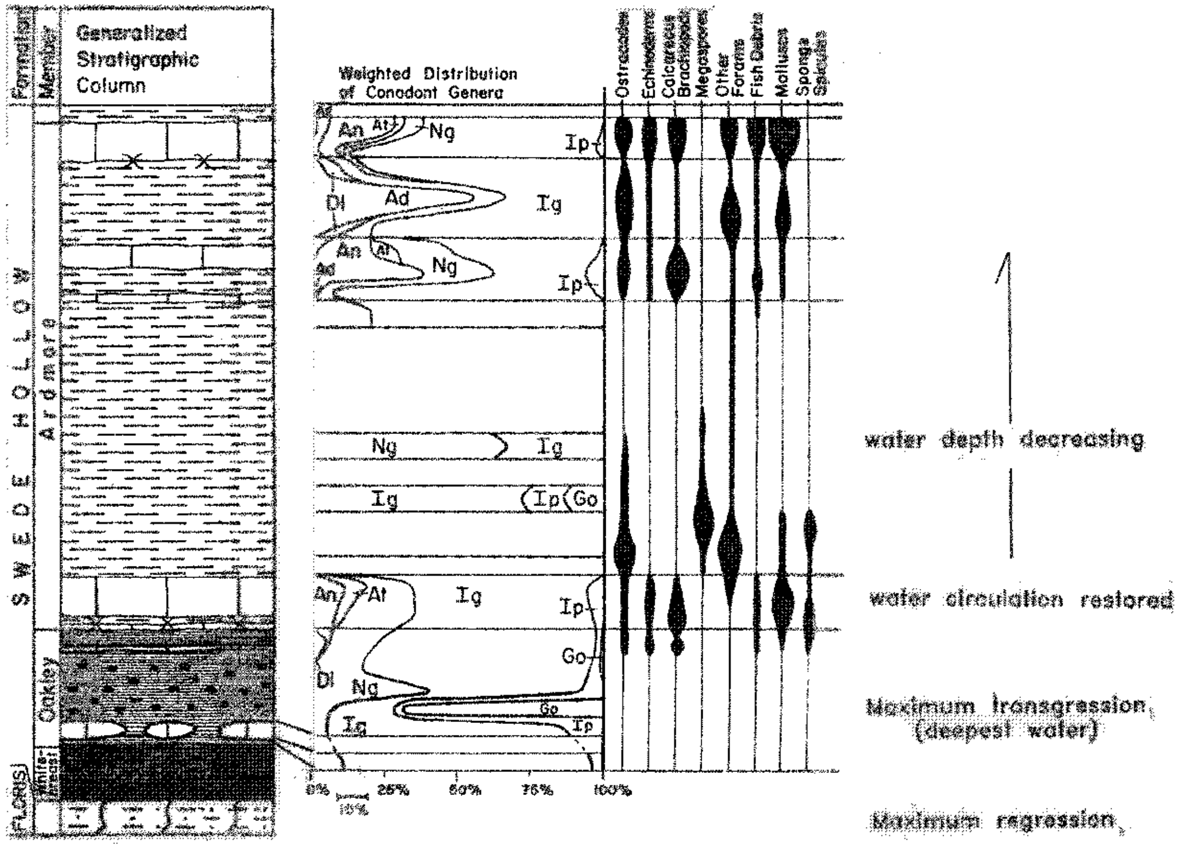

Figure 11. Detailed analysis of faunal distribution patterns within the Swede Hollow Formation strata from an IGS drill core. The abrupt shifts in abundances and distributions of species of conodonts and other fossil types are related to changes in water depth, oxygenation, and salinity. Key to conodont genera: Adetognathodus -Ad, Aethotaxis -At, Anchignathodus -An, Diplognathodus -Di, Gondolella -Go, Idiognathodus -Ig, Idioprioniodus -Ip, Neognathodus -Ng, Stepanovites -St. (after Swade, 1985).

the Ardmore Limestone is a nodular, skeletal calcilutite which averages about 0.5 ft. thick (Fig. 11). It may overlie a few inches of gray green shale that records the return of partially oxygenated bottom conditions following the deposition of the underlying anoxic Oakley Shale. The limestone originated with the return to normal vertical water circulation and fully oxygenated benthic conditions which allowed the development of carbonate-producing algae (Ravn et al., 1984).

The dark gray shale that comprises the middle of the Ardmore Limestone ranges from about four to eight feet thick in south-central Iowa. The shale typically contains intervals of burrowing and sparse fossils throughout with zones of very abundant fossils in the upper few inches (Fig. 11). The shale may represent an episode of prodeltaic deposition into water of intermediate depth as the shoreline approached the site of deposition (Swade, 1985). The presence of the fossils and bioturbation suggest deposition under marine to marginal marine influence. The dark color typical of this shale is probably the result of an influx of a large quantity of organic matter from the adjacent peat swamps to the north and east (Ravn et al., 1984).

The upper portion of the Ardmore Limestone typically consists of two thin limestone beds which are separated by a thin shale (Fig. 11). The limestones range from skeletal calcilutites to calcarenites and are slightly variable, but very persistent laterally. They represent the late phase of regression and may include evidence of very shallow shoal-water deposition, such as abraded grains. Two possible origins for the upper limestone are suggested. The upper limestone beds (i.e. "super limestone" of Heckel, 1977) probably resulted from the shifting of sediment influx from the delta which produced the middle shale bed in the Ardmore. The thin shale beds included in the upper limestone bed may have originated from a minor pulse of deltaic sedimentation. Alternatively, the widespread, uniform nature of the upper limestone suggests that it may have been deposited during a minor transgression that allowed resumption of carbonate mud production (Swade, 1985).

Deposition of the Ardmore Limestone ended in the late stage of regression, with the progradation of deltaic deposits into relatively shallow water. The influx of clastic sediment effectively halted carbonate mud production by algae and marked the maximum stage of regression (Ravn et al., 1984; Swade, 1985).

The Ardmore Limestone is correlated with the Verdigris Limestone of Missouri and Kansas, the Oak Grove Limestone of Illinois, and possibly the Velpen Limestone of Indiana (Ravn et al., 1984).

Wheeler and Bevier coals

The Ardmore Limestone is overlain by an interval of fluvial-deltaic deposits including two closely-related coal beds, the Wheeler and Bevier (Fig. 10). The interval between the Ardmore Limestone and Wheeler Coal lacks obvious evidence of subaerial weathering which would mark maximum regression, however where this interval is thin, the middle shale in the Ardmore Limestone is mottled green. The green mottling indicates partial oxidation of the organic matter during soil formation which preceded the deposition of the peat.

The Wheeler and Bevier coals are relatively widespread, although variable in thickness, but seldom exceed two feet. In southeastern and central Iowa, they are separated by an narrow interval, usually composed of silty shale. The separation generally increases to the west and southwest, but rarely exceeds 20 feet and appears to consist of a single trangressive-regressive depositional cycle. In addition, the coals are difficult to distinguish palynologically, suggesting that they may be the result of a single episode of deposition, much the same as the Laddsdale Coal.

The Bevier Coal is overlain by up to four coarsening-upward cycles of clastic sediments which were probably deposited in a fluvial-deltaic setting (Ravn et al., 1984). Locally, thin skeletal limestones are developed above the coal and zones of shale with Lingulid brachiopods or burrowing are present, suggesting a marginal marine influence. A thick, moderately widespread sandstone referred to as both Pleasantview and Pleasantville has been reported in this interval (Ravn et al., 1984; Landis and Van Eck, 1965).

The Wheeler Coal can probably be correlated with the Lowell and Shawneetown coals of Illinois. The name Bevier was carried into Iowa from Missouri, although some confusion existed as to the relationships between the Wheeler and Bevier coals. At one time, the coal which is now identified as Bevier was referred to as Bedford. However, as currently defined the Bevier coals of Iowa and Missouri are equivalent (Ravn et al., 1984). Ravn (1986) correlated the Bevier Coal with the Kerton Creek (northwest) and Roodhouse (southeast) coals of Illinois (Fig. 7).

Mulky Coal

The thin, but very widespread Mulky Coal is the uppermost unit in the Swede Hollow Formation (Fig. 9). Over most of its extent, it is present as a carbonaceous streak, but locally reaches up to five inches in thickness. The Mulky Coal marks the beginning of another eustatic marine transgressive-regressive depositional cycle.

The Mulky Coal is correlated with the Summum (No. 4) Coal of Illinois, where it reaches mineable thicknesses, and with the Mulky Coal of Missouri (Fig. 7; Ravn, 1986; Swade, 1985).

PLACEMENT OF THE ATOKAN-DESMOINESIAN BOUNDARY

The placement of the upper boundary of the Atokan Series in Iowa has been problematic. Ravn et al. (1984) and Ravn (1986) placed the boundary between the Blackoak and Cliffland coals within the Kalo Formation (Fig. 2), and the reader is referred to those works for a detailed discussion of the complexities associated with placement of the Atokan-Desmoinesian boundary in Iowa.

A definite correlation between the Blackoak Coal of Iowa and the Pope Creek Coal of Illinois has been demonstrated (Fig. 7). The Pope Creek Coal is regarded as Atokan in age, therefore, the Blackoak Coal is also regarded as Atokan (Ravn, 1986). The Rock Island Coal overlies the Pope Creek in Illinois and the Cliffland Coal overlies the Blackoak in Iowa. However, correlation between the Cliffland and Rock Island coals remains unclear. Hopkins and Simon (1975) placed the upper boundary of the Atokan Series between the Pope Creek and Rock Island coals.

Peppers (1979) placed the Atokan boundary above the Rock Island Coal. Two lines of reasoning exist for this placement. First, the miospore assemblages of the Rock Island and Cliffland coals are substantially different from the older Pope Creek and Blackoak coals and from the younger, definitely Desmoinesian coals. Second, the fusulinid Fusulinella, which is considered to be Atokan in age, is found in the Seville Limestone without the Desmoinesian fusulinids Wedekindellina and Beedeina (Heckel, pers. comm., 1988). The Seville Limestone overlies the Rock Island Coal in Illinois. In Iowa, this would place the boundary of the Atokan Series above the Cliffland Coal.

Thompson (1934) described Fusulinella iowensis but not Wedekindellina and Beedeina from a limestone which outcropped along Soap Creek in Davis County, Iowa above the coal mined at Laddsdale. As previously noted, this combination suggests an Atokan age, however, palynological analysis of the coals which fit this description showed them to be Laddsdale, which has clearly been shown to be Desmoinesian based on its miospore assemblage. Interpretation of the fusulinids as Atokan would place the upper boundary of the Atokan Series above the Laddsdale Coal in direct conflict with the age suggested by the palynolology (Heckel, pers. comm., 1988).

Recent work by Lambert on conodont collections made by Swade from the Iowa Geological Survey Bureau cores from the interval above the Cliffland Coal showed the presence of forms of Idiognathodus and Neognathodus which are considered to be Desmoinesian. The Atokan forms, Idiognathoides or Declinognathodus, were limited to samples below the Cliffland Coal in the GSB cores (Lambert, pers. comm., 1988). This would place the Atokan-Desmoinesian boundary between the Blackoak and Cliffland coals as Ravn et al. (1984) and Ravn (1986) originally suggested. This interpretation is also in agreement with the placement of the boundary suggested in Illinois by Hopkins and Simon (1975).

Clearly, further investigation will be needed to define the Atokan-Desmoinesian boundary in Iowa.

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REFERENCES

Fitzgerald, D. J., 1977, Petrology of the Pennsylvanian sandstones of Muscatine County, Iowa: unpublished M.S. thesis, University of Iowa, 215 p.

Gleim, D. T., 1955, Stratigraphy and paleontology of the Lower Pennsylvanian rocks in southern Iowa: unpublished Ph. D. dissertation, University of Iowa, 212 p.

Gregory, J. L., 1982, The stratigraphy and depositional environments of the Kalo Formation (Pennsylvanian) of south-central Iowa: unpublished M. S. thesis, University of Iowa, 218 p.

Heckel, P. H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothems of Midcontinent North America: American Association of Petroleum Geologists Bulletin, v. 61, p. 1045-1068.

Hopkins, M. E. and Simon, J. A., 1975, Pennsylvanian System: in Willman, H. B., et al., Handbook of Illinois Stratigraphy, Illinois State Geological Survey Bulletin 95, p. 163-201.

Landis, E. R., and Van Eck, O. J, 1965, Coal resources of Iowa: Technical Paper 4, 141 p.

Peppers, R. A., 1979, Development of coal-forming floras during the early part of the Pennsylvanian in the Illinois Basin: in Palmer, J. E., and Dutcher, R. R., eds., Depositional and Structural History of the Pennsylvanian System of the Illinois Basin, 9th International Congress Carboniferous Stratigraphy and Geology, Illinois State Geological Survey, Guidebook Series 15a, part 2, p. 8-14.

Ravn, R. L., 1986, Palynostratigraphy of the Lower and Middle Pennsylvanian coals of Iowa: Iowa Geological Survey Technical Paper 7, 245 p.

Ravn, R. L., Swade J. W., Howes, M. R., Gregory, J. L., Anderson, R. R., and VanDorpe, P. E., 1984, Stratigraphy of the Cherokee Group and revision of Pennsylvanian stratigraphic nomenclature in Iowa: Iowa Geological Survey Technical Information Series 12, 76 p.

Searight, W. V., Howe, W. B., Moore, R. C., Jewett, J. M., Condra, G. E., Oakes, M. C., and Branson, C. C., 1953, Classification of Desmoinesian (Pennsylvanian) of northern Mid-Contintent: American Association of Petroleum Geologists Bulletin, v. 37, p. 2747-2749.

Stookey, D. G., 1935, Stratigraphy of the Des Moines Series of southeastern Iowa: unpublished Ph.D. dissertation, University of Iowa.

Swade, J. W., Heckel, P. H., ed., 1985, Conodont distribution, paleoecology, and preliminary biostratigraphy of the upper Cherokee and Marmaton Groups (Upper Desmoinesian, Middle Pennsylvanian) from two cores in south-central Iowa: Iowa Geological Survey Technical Information Series 14, 71 p.

Thompson, M. L., 1934, The fusulinids of the Des Moines Series of Iowa: Iowa University Studies in Natural History, v. 16, no. 4, p. 277-332.

PALYNOLOGY OF CHEROKEE GROUP COALS

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INTRODUCTION

The stratigraphic framework of the Cherokee Group was established by correlating between drill cores and outcrops using zonations based on miospores recovered from coals. Over 300 species of miospores have been identified from Iowa coals but only a fraction of these are abundant enough and restricted enough in range to be stratigraphically useful. The zonations are defined by appearances and extinctions of certain miospores. Relative abundances of other miospores are useful for correlation, especially in the upper part of the Cherokee Group (Ravn et al., 1984).

The following discussion is largely an excerpt from Ravn (1986), an excellent guide to the palynostratigraphy of the Lower and Middle Pennsylvanian of Iowa. The reader is referred to that publication for further discussion.

Detailed studies of miospores from the Iowa Geological Survey Coal Resource Program (obtained during the 1970's) cores revealed a series of palynological "events" that were of regional significance for corrrelation of Iowa coal beds. Parallel events are documented across North America and Europe and form a useful basis for long range comparisons. The significant occurrences are summarized, in ascending stratigraphic order as follows:

1. Extinction of Schulzospora spp.
2. Appearance of Endosporites globiformis.
3. Extinction of Sinuspores (Punctatisporites) sinuatus. (approx. = extinction of Grumosisporites varioreticulatus).
4. Appearance of Torispora securis.
5. Extinction of Dictyotriletes bireticulatus. (approx. = extinctions of Densosporites annulatus and Retispora staplinii).
6. Appearance of Microreticulatisporites sulcatus.
7. Appearance of Thymospora spp.
8. Appearance of Schopfites dimorphus. (approx. = appearance of Cadiospora magna).

In addition to the palynological events listed above several other miospore taxa have ranges which are stratigraphically important in the Cherokee coals of Iowa. The ranges of those spores which are most important in terms of their usefulness for correlating between exposures in Iowa are shown in Figure 1. Both the taxa with long range and local usefulness are included on the range chart. The spores are illustrated in Figures 2 and 3.

PALYNOSTRATIGRAPHY

The following is a discussion of the important palynological characteristics of the Cherokee coals. It summarizes the work of Ravn (1979, 1986) and Egner (1981). For a more detailed discussion the reader is referred to those sources.

Kilbourn Formation Coals

The Kilbourn Formation, at the base of the Cherokee Group, records the infilling of erosional irregularities on the Mississippian surface. The coals are lenticular and formed under the influence of local environmental factors. As a result the miospore assemblages of Kilbourn coals are highly variable. Several species of lycopsid-related "densospores" (i.e. spores with thick cingula) often are abundant, including Densosporites annulatus (Fig. 3-2), Radiizonates difformis and Cristatisporites indignabundas.

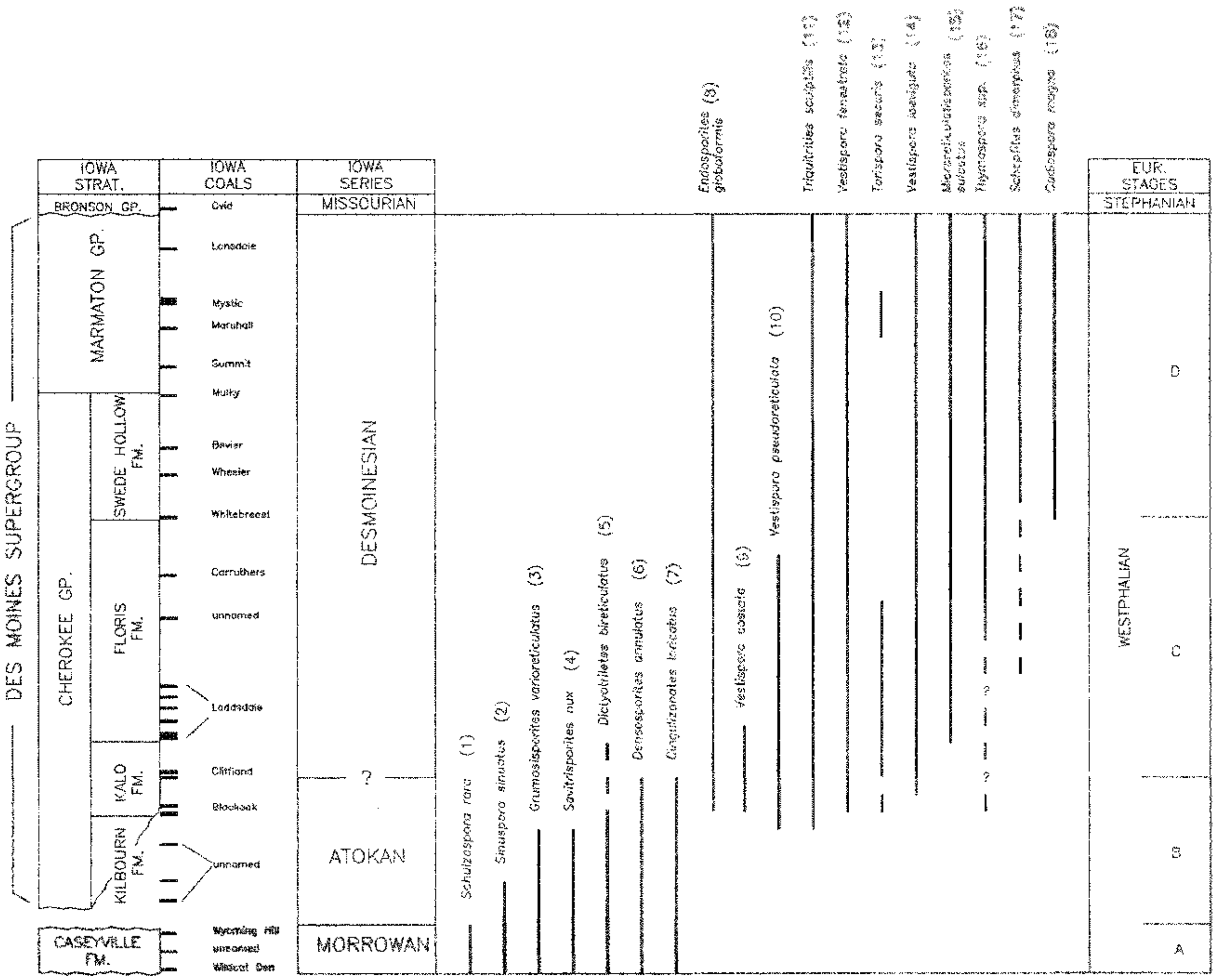

Figure 1. Range chart of stratigraphically significant miospores of the Morrowan, Atokan, and Desmoinesian series in Iowa. Many of the miospores included in this chart are useful for comparisons with palynological "events" on regional and worldwide scales.

Lycospora spp. dominate in many Kilbourn coals and Florinites spp. are abundant. Several important genera make their earliest appearances in Kilbourn coals. These include Alatisporites, Vestispora (Fig. 3), and Triquitrites (Fig. 3). The distinctive species Cyclogranisporites aureus also makes its first appearance in the Kilbourn coals.

Kalo Formation Coals

Two major coals occur in the Kalo Formation. The lowermost of these is the Blackoak Coal which is the oldest widespread coal in Iowa and its deposition occurred under a significantly different paleoenvironment than had previously existed. The Blackoak Coal is notable for the extreme diversity of the miospore assemblage which it contains. Important spores which make their first appearance in the Blackoak Coal include Torispora securis (Fig. 3-7) and Triquitrites tribullatus, both of which are very abundant. A number of other species which are minor components of the miospore assemblage also appear for the first time in the Blackoak Coal. Important taxa which appear regularly for the last time in the Blackoak Coal include

Dictyotriletes bireticulatus, Savitrisporites nux (Fig. 3-3), Knoxisporites triradiatus, Cristatisporites indignabundus, Radiizonates difformis, Densosporites annulatus (Fig. 3-2), Densporites irregularis, and Retispora staplinii. Changes in abundance of certain miospore taxa also appear to be important in the Blackoak Coal. Among these are several species of Laevigatosporites and Vestispora, and Microreticulatisporites nobilis which become much more common in the Blackoak Coal than in older coals.

The Cliffland Coal, the upper coal in the Kalo Formation, like the Blackoak Coal, is variable but widespread. The major constituents and abundances of the miospore assemblage of the Cliffland Coal resemble those of the Blackoak Coal so that the two coals are not always easily differentiated on the basis of palynology. The Cliffland assemblage is typically somewhat lower in diversity, lacking the species which became extinct in the Blackoak. Lycospora spp. constitute a smaller portion of the assemblage while Punctatisporites glaber, Cyclogranisporites obliquus, Laevigatosporites minor and L. desmoinesensis, Florinites mediapudens, Dictyomonolites swadei, and Spackmanites spp. become more abundant. Murospora kosankei appears in the Cliffland Coal for the first time.

Floris Formation Coals

The lithologically complex Laddsdale Coal consists of from one to six coal seams which are related. Palynological correlation of individual coal beds proved to be impossible. The miospore assemblages remain diverse in comparison to younger coals and resemble, in major constituents, the older Blackoak and Cliffland coals. The Laddsdale complex is distinguished by the earliest regular occurrences of Microreticulatisporites sulcatus (Figs. 3-9,10) and Mooreisporites inusitatus. Quasillinites diversiformis and Peppersites ellipticus, Verrucosisporites verrucosus, Verrucosisporites sifatii, Lophotriletes ibrahimii, Pilosisporites williamsii, Convolutispora florida, Vestispora clara, Cuneisporites rigidus, Zosterosporites triangularis make their final appearance in the Laddsdale coals. A number of spores identify the Laddsdale coals on the basis of their greater relative abundances. They are Lycospora rotunda, Reticulatisporites reticulatus, and Alatisporites trialatus.

The unnamed coal in the Floris Formation which lies above the Laddsdale is thin, but relatively persistent. The miospore assemblage which it contains is usually poorly preserved and impoverished. Its most important palynological characteristic is the first occurrence of Thymospora pseudothiessenii (Figs. 3-11,12). It also marks the last regular occurrence of Torispora securis (Fig. 3-7). Lycospora granulata is typically dominant with abundant Densosporites sphaerotriangularis and D. triangularis also noted.

The Carruthers Coal is the uppermost named member in the Floris Formation. The miospore assemblages are generally of low diversity with no stratigraphically useful species. For this reason, coal seams were usually assigned to the Carruthers on the basis of associated strata and its position immediately below the Swede Hollow Formation. Lycospora granulata, Densosporites sphaerotriangularis, D. triangularis, and Granasporites medias are usually most abundant in the Carruthers Coal.

Swede Hollow Formation Coals

Correlations within the Swede Hollow Formation rely more heavily on lithologic evidence than in the older strata for two reasons. First, the Swede Hollow Formation includes a number of readily recognizable lithologic units which persist over large geographic areas. Second, the diversities of miospore assemblages found in Swede Hollow coals tend to be lower than in older coals so palynological distinctions are more difficult.

The Whitebreast Coal includes the first appearances of several important taxa. These are Schopfites dimorphus (Fig. 3-13), Raistrickia subcrinita, and Triquitrites spinosus. The Whitebreast Coal also marks the last occurrence of Densosporites spp. as an important constituent. The lithologic uniformity of the Whitebreast Coal is paralleled by uniformity in the miospore assemblage with very little diversity noted between samples. Overall diversity is moderate and Lycospora granulata dominates.

The Wheeler and Bevier coals are difficult to distinguish palynologically which may further indicate that they are related depositionally. Cadiospora magna (Fig. 3-14) and Raistrickia crinita appear for the first time in these coals. Both coals are usually dominated by Lycospora granulata, although the abundance tends to be slightly lower in the Bevier Coal.

The Mulky Coal is the uppermost unit in the Swede Hollow Formation. No significant diagnostic miospores have been found in it, although only a few samples were available for study. Lycospora pellucida and L. granulata each constitute about 25% of the assemblage and Illinites unicus was commonly observed.

REFERENCES

Egner, B. E., 1981, A palynological analysis of fourteen coals from the Cherokee Group (Pennsylvanian), Marion County, Iowa: unpublished M.S. thesis, University of Iowa, 166 p.

Ravn, R. L., 1986, Palynostratigraphy of the lower and middle Pennsylvanian coals of Iowa: Iowa Geological Survey Technical Paper 7, 245 p.

Figure 2. Spores shown on range chart (Fig. 1). Numbers in parentheses correspond to numbers on chart. Sizes are given in microns except for scanning electron microscope images (SEM) which are given as magnifications.

1. Schulzospora rara 62.7
2. Sinuspores sinuatas SEM 600X
3. Grumosisporites varioreticulatus SEM 600X
4. Grumosisporites varioreticulatus 106.5
5. Dictyotriletes bireticulatus 42.8
6. Savitrisporites nux 58.7
7. Endosporites globiformis 122.1
8. Dictyotriletes bireticulatus SEM 900X

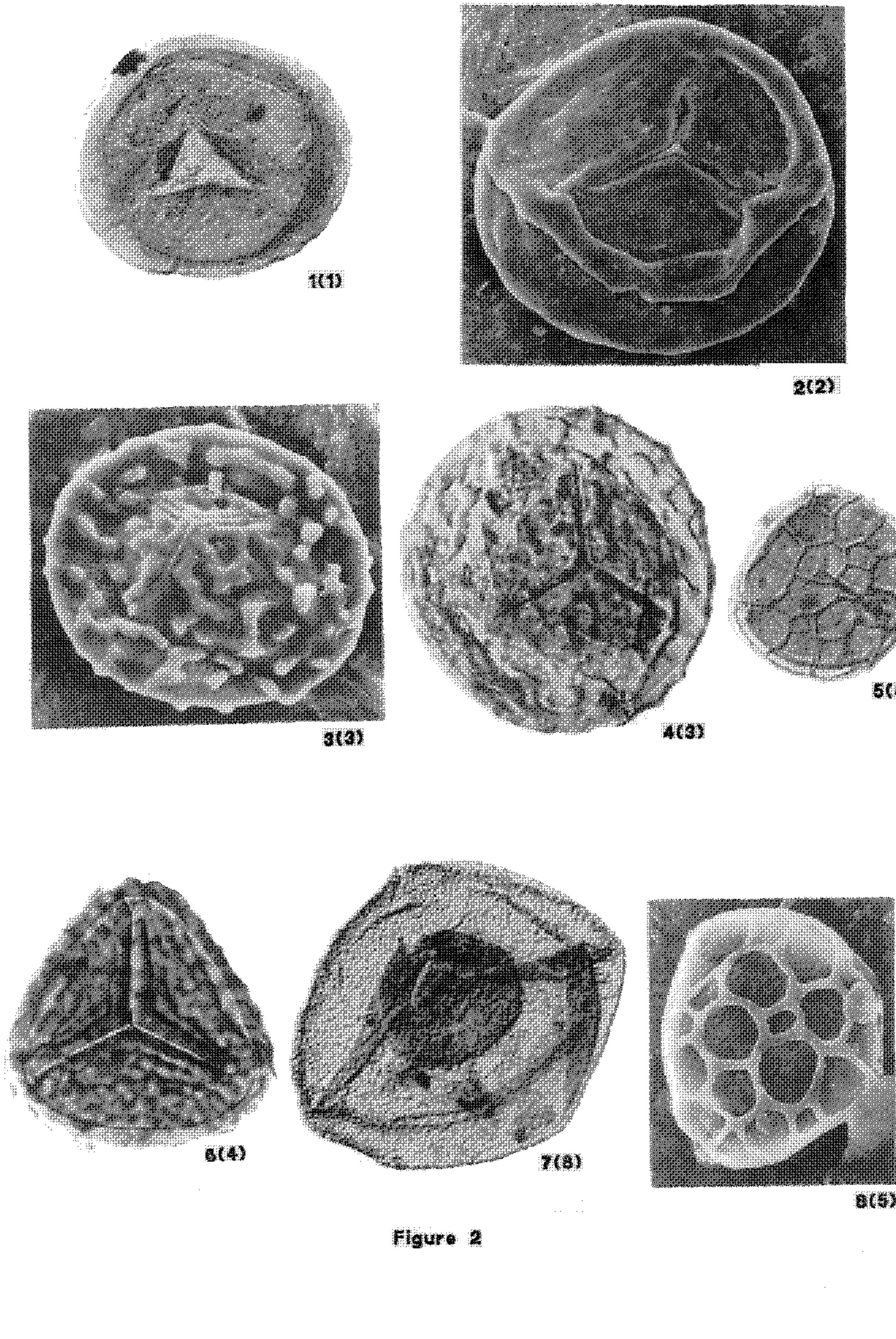

Figure 2

Figure 3. Spores shown on range chart (Fig. 1). Numbers in parentheses correspond to numbers on chart. Sizes are given in microns except for scanning electron microscope images (SEM) which are given as magnifications.

1. Vestispora costata 69.0
2. Densosporites annulatus 35.9
3. Cingulazonates loricatus 44.0
4. Triquitrites sculptilis 34.8
5. Vestispora laevigata 95.1
6. Vestispora pseudoreticulata 65.5
7. Torispora securis 39.9
8. Vestispora fenestrata 68.4
9. Microreticulatisporites sulcatus 45.1
10. Microreticulatisporites sulcatus SEM 800X
11. Thymospora pseudothiessenii 31.4
12. Thymospora pseudothiessenii 29.6
13. Schopfites dimorphus 66.7
14. Cadiospora magna 82.3

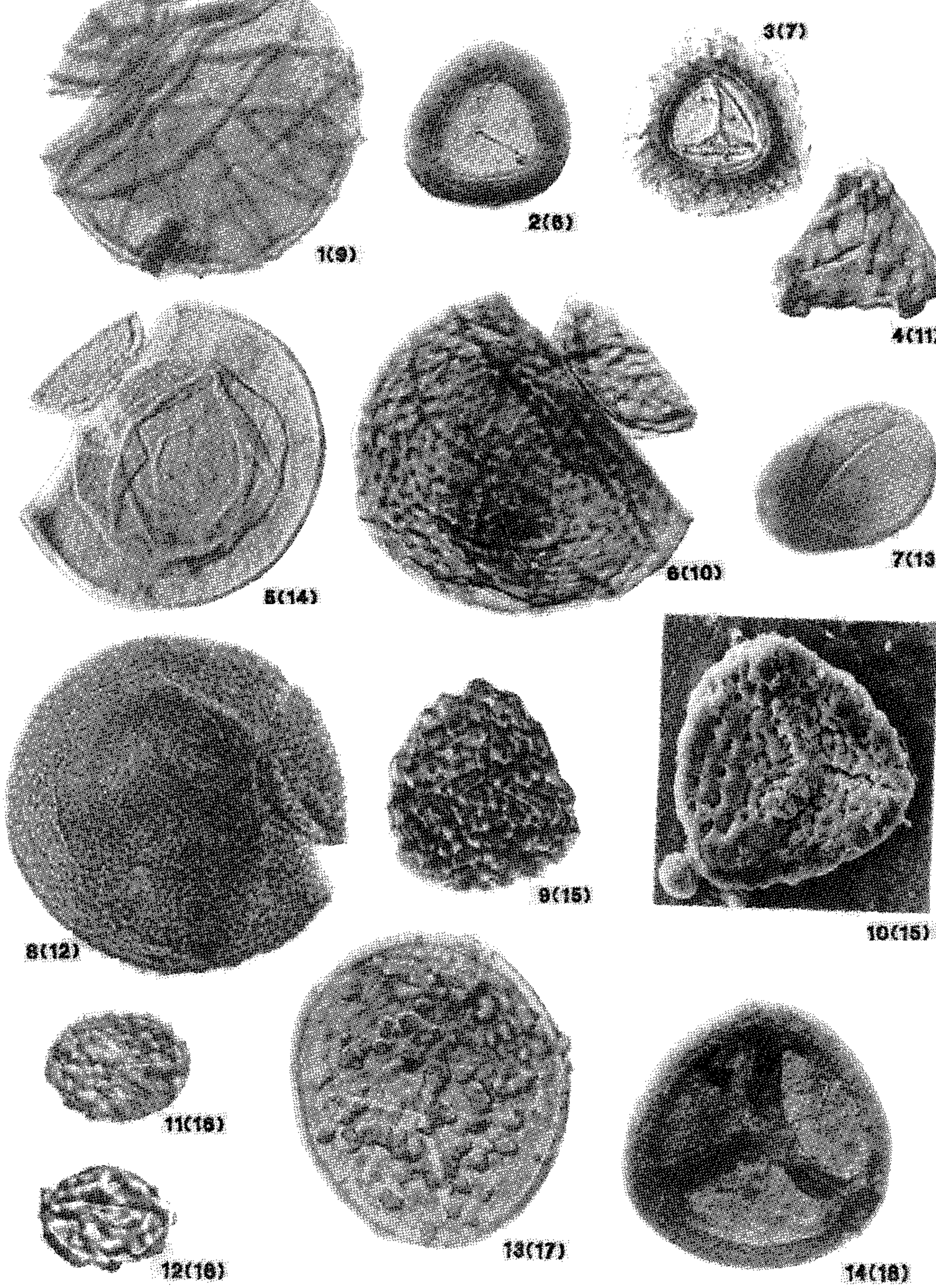

Figure 3

FUSULINIDS FROM THE CHEROKEE GROUP OF IOWA

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INTRODUCTION

"Fusulinid" is an informal term used to refer to foraminifers (Class Sarcodina) of the extinct superfamily Fusulinacea. Their coiled tests are abundant in many rocks of the Pennsylvanian and Permian systems in the Midcontinent and elsewhere, even though their distribution is to a significant degree controlled by paleoecological factors. These organisms evolved rapidly throughout their stratigraphic range, and attained a surprising degree of complexity as well as a rather large size for "microfossils" (often one cm or more long in the Pennsylvanian). These characteristics, along with a great deal of study earlier in the present century, have made fusulinids important biostratigraphic tools for the rocks in which they are found.

Fusulinids must be sliced thinly enough for light to pass through the shell wall in preparation for any detailed study. The most useful sections pass through the initial chamber (called the proloculus) and lie parallel to the long axis of the test. Such a section is the only one that can reveal the true dimensions of all stages of growth as well as internal secondary deposits. Taxonomy at the specific level is based in part on measurements of particular components of the shell seen in axial section, in addition to the type of wall structure and the shape of the test (Figs. 1 and 2).

FUSULINIDS AND THE ATOKAN/DESMOINESIAN BOUNDARY

The first systematic study of fusulinids from the Cherokee Group of Iowa was completed by M. L. Thompson (1934). In that study he erected the taxon Fusulinella iowensis for an inflated, advanced species of that genus, which was recovered from approximately 20 feet above the Mississippian/Pennsylvanian contact. Numerous species assigned to the genera Wedekindellina and Fusulina (=Beedeina of present usage; see Ishii, 1958) were also described from higher in the Cherokee (Thompson 1934). Almost as an aside in another publication, Thompson (1942) related that he later recovered primitive specimens of Beedeina from the same horizon as F. iowensis. No detailed studies published since have had the lower Cherokee of Iowa as a primary focus, although researchers from several major oil companies have made extensive collections (e.g., Sanderson and West, 1981).

This question of co-occurrence is an important point to consider. The first fusiform ("football"-shaped) fusulinid in the geologic record is Profusulinella, a small genus whose stratigraphic range encompasses rocks of middle Atokan age (Groves, 1986). The succeeding Fusulinella zone is used to denote the upper Atokan as currently recognized by most stratigraphers. The base of the Beedeina zone is defined on the first occurrence of either Beedeina or Wedekindellina. Since the publication of Moore and Thompson (1949), the majority of stratigraphers have equated the zone of Beedeina with the Desmoinesian. Confusion stems from the fact that, although the Fusulinella zone is interpreted to "define" the upper Atokan, species of that genus range into the overlying Beedeina zone. In other words, the upper range of Fusulinella overlaps the lower ranges of Beedeina and Wedekindellina. However, many faunas from strata in which this overlap occurs are composed exclusively of Fusulinella or Beedeina and/or Wedekindellina. Because of taxonomic uncertainties at the species level, many workers have overlooked or disregarded this stratigraphic overlap. Other fusulinid genera that are commonly found with the zonal indicators are themselves not diagnostic of any particular zone.

For the majority of stratigraphers who consider the Beedeina zone to be equivalent with the Desmoinesian series, an "upper Atokan" in the type Desmoinesian region is often considered to be delineated by the range of F. iowensis below the zone of Beedeina. Conversely, Shaver (1984) suggested that the base of the Desmoinesian should be recognized at the lowest occurrence of F. iowensis to more closely approximate the original definition of the series. The recovery of thick sequences of pre-Beedeina zone strata from cores drilled in the type Desmoinesian area further complicates the issue, because a continuous rock sequence from the type region is available only in the form of cores. Additionally, fusulinid taxonomy at the species level is currently rather unreliable, with population variation poorly understood (Bebout, 1963; Sanderson and Verville, 1970) and with very similar forms from different geographical regions often taxonomically segregated. The result is that there are major difficulties in correlation based on fusulinid species. These difficulties are compounded by the group's susceptibility to paleoecological control of distribution. The concept behind formal recognition of series is for purposes of correlation. Therefore, any definition of the Desmoinesian formulated at this time probably should be based on a widespread taxon from some group other than the fusulinids.

FUSULINIDS FROM THE PRESENT OUTCROPS

The only abundant fusulinids recovered from the current field trip stops occur within the shale 1.5 to 2.0 feet below the thick limestone overlying the Laddsdale coal at STOP 1. These specimens are extremely small for Middle Pennsylvanian fusulinids, and many of them are the tests of juveniles rather than adults. Most of these specimens represent somewhat "primitive" forms of the genus Beedeina. Therefore this outcrop represents strata from the Beedeina zone. Notably, some of the remaining forms are quite similar to the species Fusulinella cadyi which was described by Dunbar and Henbest (1942) from Illinois. This species represents one of the youngest occurrences of the genus Fusulinella. A variety of general shapes can be seen with a hand-lens and compared with the figures accompanying this article.

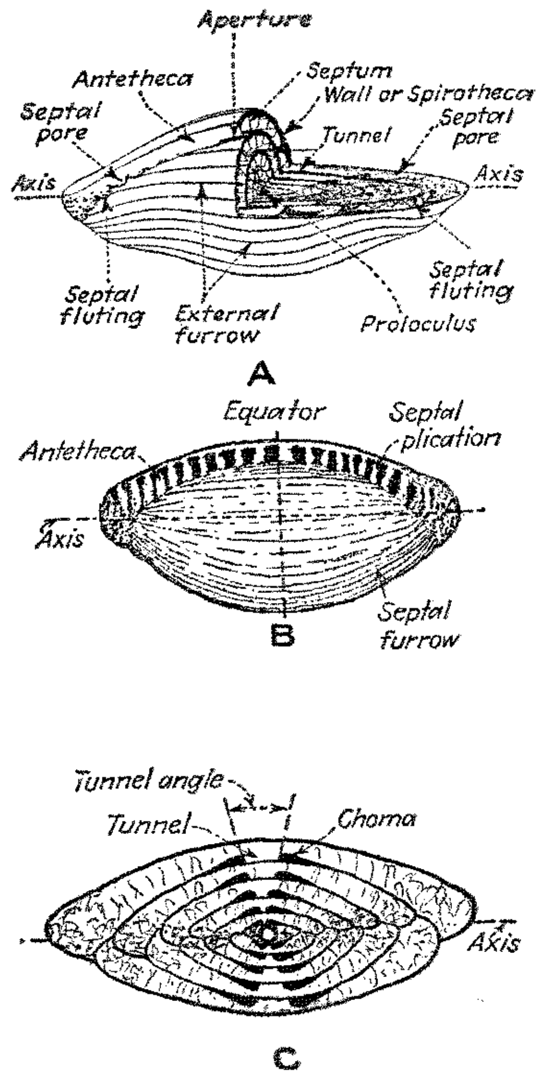

Figure 1. Structure of fusulinid tests. A. Diagram of partly sectioned test, showing typical structures. B. External view. C. Axial view. From Shrock and Twenhofel, 1953.

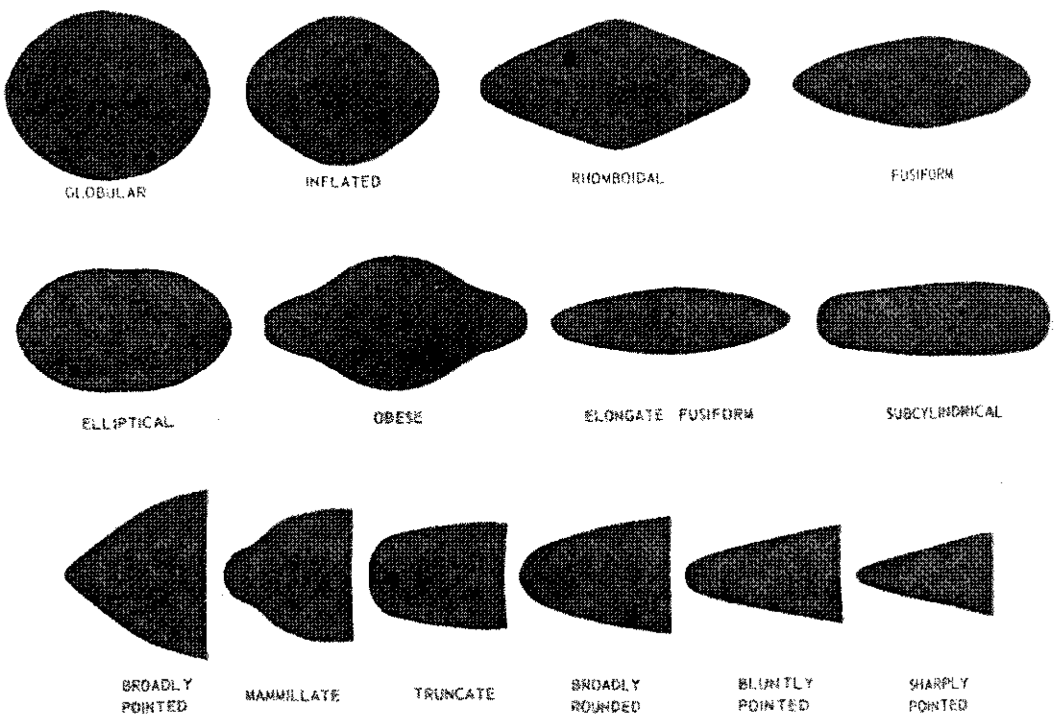

Figure 2. Shape terminology of mature fusulinids and their polar extremities. From Waddell, 1966.

REFERENCES

Bebout, D. G., 1963, Desmoinesian fusulinids of Missouri: Missouri Surv. and Water Res. Report of Invest. #28, 79 p.

Dunbar, C. O. and L. G. Henbest, 1942, Pennsylvanian fusulinidae of Illinois: Illinois Geol. Surv. Bull. #67, 218 p.

Groves, J. R., 1986, Foraminiferal characterization of the Morrowan-Atokan (lower Middle Pennsylvanian) boundary: GSA Bull., v. 97, #3, p. 346-353.

Ishii, K., 1958, On the phylogeny, morphology and distribution of Fusulina, Beedeina and allied fusulinid genera: Journal Inst. Polytechnics, Osaka City Univ., Ser. G, v. #4, p. 29-70.

Moore, R. C. and M. L. Thompson, 1949, Main divisions of Pennsylvanian period and system: AAPG Bull., v. 33, #3, p. 275-302.

Sanderson, G. A. and G. J. Verville, 1970, Morphologic variability of the genus Schwagerina in the Lower Permian Wreford Limestone of Kansas: Palaeontology, v. 13, #2, p. 175-183.

Sanderson, G. A. and R. R. West, 1981, Fusulinids from the Desmoinesian type area: GSA Abst. with Prog., v. 13, p. 545.

Shaver, R. H., 1984, Atokan series concepts with special reference to the Illinois Basin and Iowa: Oklahoma Geol. Surv. Bull., #136, p. 101-113.

Shrock, R. R. and W. H. Twenhofel, 1953, Principles of invertebrate paleontology: McGraw-Hill, New York, 816 p.

Thompson, M. L., 1934, The fusulinids of the Des Moines series of Iowa: Iowa Univ. Studies Nat. Hist., v. 16, p. 277-332.

Thompson, M. L., 1942, Pennsylvanian system in New Mexico: New Mexico Sch. of Mines Bull., #17, 90 p.

Waddell, D. E., 1966, Pennsylvanian fusulinids in the Ardmore Basin, Love and Carter Counties, Oklahoma: Oklahoma Geol. Surv. Bull., #113, 128 p.

CHEROKEE GROUP CONODONTS FROM SOUTHEASTERN IOWA

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INTRODUCTION

Conodonts are the tooth-shaped hard parts of an extinct group of marine organisms whose soft parts are very rarely preserved (Briggs et al., 1983; Mikulic et al., 1985; Aldridge et al., 1986). These organisms thrived worldwide in predominantly warm marine waters from the Cambrian through the Triassic periods. Although many groups of conodont organisms appear to have been facies independent and thus probably nektonic, many others were distinctly influenced in distribution by subtle paleoenvironmental parameters and were more likely nektobenthic. The conodont elements themselves are microscopic (only up to 3 mm along their maximum axis) and are composed of calcium phosphate (Fig. 1). Conodonts are excellent biostratigraphic tools because they are abundant, widely distributed, easily recovered from the majority of lithologies, and they evolved rapidly. In portions of the geologic record, conodont zones attain an extremely fine resolution representing less than a million years duration.

Pennsylvanian conodonts have traditionally been interpreted as long-ranging forms with little potential for such precise biostratigraphic zonation. Additionally, many Pennsylvanian specialists have considered the dominant taxon, Idiognathodus, to show extreme ecophenotypic variability--thus rendering it difficult to utilize for biostratigraphy. As a consequence, most biostratigraphic schemes have been based on the sporadic occurrences of less common taxa, most of which show high degrees of morphological convergence at the specific level. While biostratigraphic zonations based upon these less common taxa are generally reliable, much more precise zonations using Idiognathodus appear to be possible.

Much of the complexity in Pennsylvanian conodont work, particularly with regard to Idiognathodus, arises from a history of poor taxonomic practice. Phylogenetic patterns are obscured by formal description of juvenile forms and "ecophenotypic" variants. Taxonomic revisions based on general morphological characters have resulted in the synonymization of various taxa from significantly different stratigraphic horizons. As interest in Pennsylvanian conodont faunas has increased worldwide, taxa have continued to be erected in much the same manner, without sufficient reference to previous systematic studies. However, with strict attention to stratigraphy and careful comparison with named types, these historical problems can be overcome with concerted effort.

CHEROKEE CONODONTS AND THE ATOKAN/DESMOINESIAN BOUNDARY

The recognition of a broadly accepted Atokan/Desmoinesian "chronostratigraphic" boundary is complicated by several factors, including sparsely fossiliferous lithologies in the type Atokan area, a prominent unconformity of variable extent at the base of the Pennsylvanian in the type Desmoinesian area, and the apparent overlap of equivalent strata within both type regions. Furthermore, since the publication of Moore and Thompson (1949), correlations with these series have generally been based on the standard fusulinid zonation rather than on type sections with clearly defined boundaries. Thus, the significant stratigraphic overlap in the type areas (neither of which possess a designated type section) has resulted in biostratigraphic confusion as well.

Although some workers have stated that strict priority should determine the formal recognition

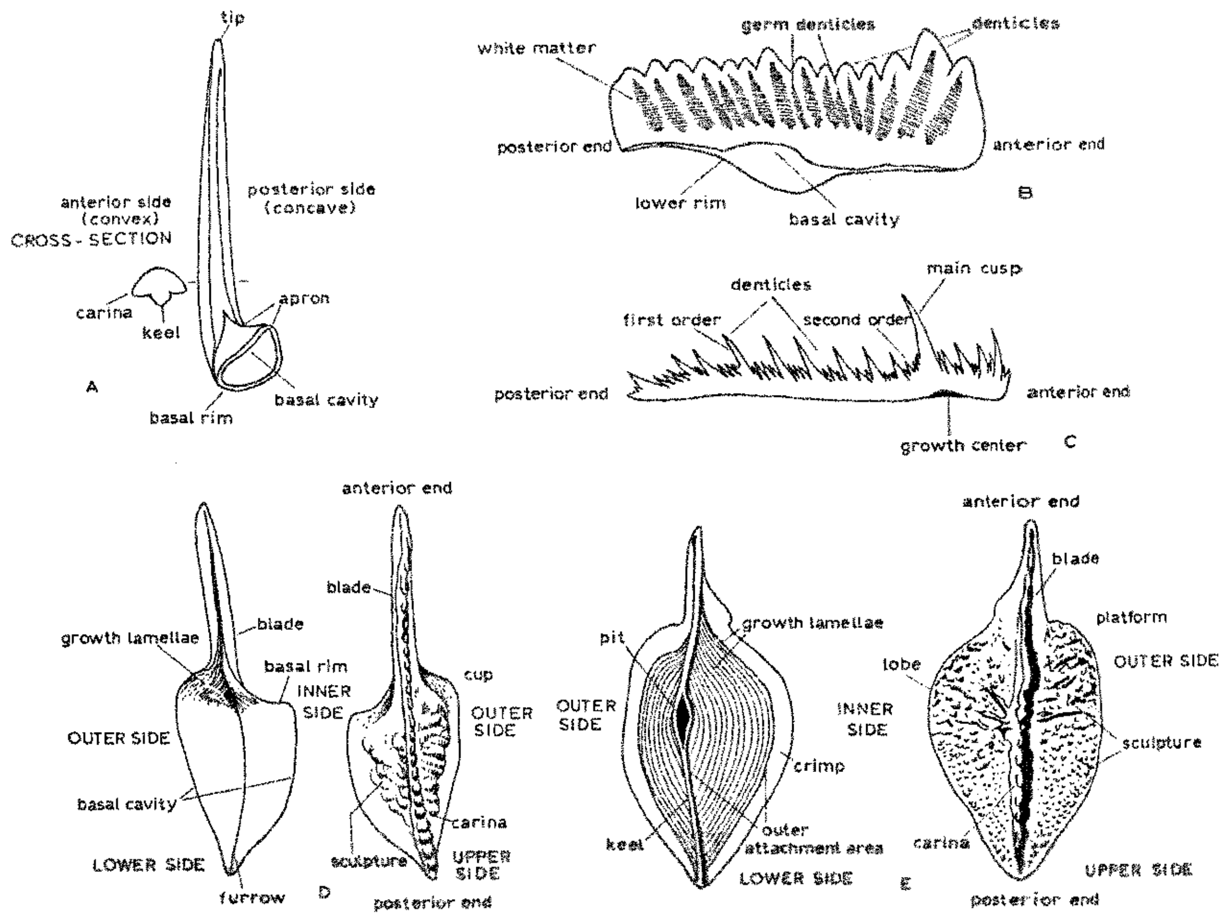


Figure 1. Features of different kinds of conodonts. A. Single-cone type, B. "Blade" type, C. "Bar" type, D. Platform type (Gnathodus), E. Platform type (Polygnathus). from Müller, 1978.

of series boundaries (Shaver 1984), neither semantical nor conceptual problems would be solved in this particular instance. The ensuing dramatic changes would result in great confusion, both with regard to altering present definitions and later in referring to the older literature. A less disruptive method would be to select a widespread taxon to mark the base of the Desmoinesian, and then to define a type section for the boundary in which that designated taxon is well represented. The preliminary results expressed in this guidebook suggest that both conodonts and palynomorphs could provide an excellent common boundary not far removed stratigraphically from the one recognized historically based on fusulinids. In addition, this boundary is already becoming well delineated in the type Desmoinesian area. A significant feature of this horizon is that it can be recognized in both marine and terrestrial deposits.

SPECIMENS FROM FIELD TRIP LOCALITIES

Conodonts have been obtained from each of the stops that we will be making on this field trip (map on back cover). The abundance of specimens varies considerably among samples as well as among localities. This distribution reflects both the influence of lateral changes in paleoenvironmental conditions and the degree of marine versus terrestrial deposition of individual formations. Elsewhere in this guidebook, Howes summarizes the depositional history of the Cherokee Group in Iowa, describes each formation and its named members, and lists some of its correlatives in neighboring states.

Because this discussion is a preliminary report of research in progress, open nomenclature will be used except for established taxa in discussing the faunas. Nevertheless, the purpose of this article is to point out the potential that these conodonts provide for zonation of the Iowa Cherokee into relatively fine biostratigraphic units. Furthermore, such results suggest that these deposits can be utilized as an effective type area for the Desmoinesian series, despite various claims to the contrary (e.g. Sanderson and West, 1981; Lane and West, 1984).

The strata encountered on this trip represent two formations of the Cherokee Group in Iowa, the Kalo and the Floris formations (Fig. 2 in Howes, p. 3). To maintain continuity with the other reports in this guidebook, each fauna will be referred to in terms of an interval delineated by widespread coals. The stratigraphically lowest fauna is that associated with the Blackoak Coal in the Kalo formation. Diagnostic conodonts from the limestone above the Blackoak at STOP 3 are Neognathodus bothrops and a species of Idiognathodus similar to one assigned by Grubbs (1984) to Streptognathodus sp. aff. S. wabaunsensis. The fauna above the overlying Cliffland coal differs from the preceding one with respect to both genera. Neognathodus sp. A was the only species of that genus recovered, while three different species of Idiognathodus replace the former one. The marine portion of the Cliffland interval at STOP 3 includes both a black shale and a well-developed limestone. The conodont faunas are identical in both lithologies, but conodonts are significantly more abundant in the shale. It is evident that the Kalo formation can be divided into two intervals based on conodonts. These intervals are distinct, and the boundary between them represents the same one as that used to separate the Atokan from the Desmoinesian series in Iowa according to palynomorphs (Ravn et al., 1984; Ravn, 1986; Heckel and Lambert, 1987). Corroborating data from the subsurface strengthens these stratigraphic assignments. Samples from Iowa cores processed and initially studied by John Swade of the Iowa Geological Survey during the 1970s reveal that the genera Idiognathoides and Declinognathodus do not range above the Blackoak interval. These taxa are usually considered to be restricted to the Atokan series, particularly in the Midcontinent region.

The lower interval of the Floris formation (STOPS 1 and 2) is characterized by specimens of a group of conodonts collectively referred to the taxon Neognathodus medadultimus sensu lato. The idiognathodids present in this fauna appear to belong to the same taxa as those from the Cliffland interval at STOP 3. Samples from the Carruthers interval, higher in the Floris formation (STOP 4), produce a suite of Idiognathodus species different from those recovered in the Laddsdale interval. It appears that only a single species of Idiognathodus common in the Laddsdale interval ranges upwards into the Carruthers interval. Representatives of the genus Neognathodus are present in the Carruthers interval as somewhat different forms of N. medadultimus sensu lato, and can be easily distinguished from the earlier neognathodids. This interval also produces the only specimens of the genus Gondolella recovered from the field trip stops.

SUMMARY

Significantly, the normal marine deposits associated with each named coal interval of the Kalo and Floris formations can be characterized by their component conodont faunas. Furthermore, a consistent candidate horizon for the Atokan/Desmoinesian boundary can be recognized using these faunas, both from the subsurface and from outcrops in southeastern Iowa. This horizon lies between the Blackoak and Cliffland coal intervals, as does the boundary based on palynomorphs. Therefore, it is possible to establish a very useful boundary stratotype in the type Desmoinesian region.

ACKNOWLEDGMENTS

My gratitude is extended to Rebecca Lambert for help in processing samples, and to Bill

Furnish, Phil Heckel, Mary Howes, and Ron Metzger for discussion and assistance in the field on various occasions regarding these articles.

REFERENCES

Aldridge, R. J., D. E. G. Briggs, E. N. K. Clarkson, and M. P. Smith, 1986, The affinities of conodonts - new evidence from the Carboniferous of Edinburgh, Scotland: Lethaia, v. 19, p. 279-291.

Briggs, D. E. G., E. N. K. Clarkson, and R. J. Aldridge, 1983, The conodont animal: Lethaia, v. 16, #1, p. 1-14.

Grubbs, R. K., 1984, Conodont platform elements from the Wapanucka and Atoka formations (Morrowan-Atokan) of the Mill Creek Syncline, central Arbuckle Mountains, Oklahoma: Oklahoma Geol. Surv. Bull., #136, p. 65-79.

Heckel, P. H. and L. L. Lambert, 1987, Preliminary comment on problems associated with the Atokan-Desmoinesian boundary in Iowa: unpub. report to SEPM Mid-Cont. Penn. Strat. Working Group.

Lane, H. R. and R. R. West, 1984, The inadequacies of Carboniferous serial nomenclature: North American examples: Oklahoma Geol. Surv. Bull., #136, p. 91-100.

Mikulic, D. G., D. E. G. Briggs, and J. Kluessendorf, 1985, A Silurian soft-bodied biota: Science, v. 228, p. 715-717.

Moore, R. C. and M. L. Thompson, 1949, Main divisions of Pennsylvanian period and system: AAPG Bull., v. 33, #3, p. 275-302.

Müller, K. J., 1978, Conodonts and other phosphatic microfossils: p. 277-291, in Introduction to marine micropaleontology, B. U. Haq and A. Boersma eds, Elsevier, 376 p.

Ravn, R. L., 1986, Palynostratigraphy of the Lower and Middle Pennsylvanian coals of Iowa: Iowa Geol. Surv. Tech. Pap. #7, 245 p.

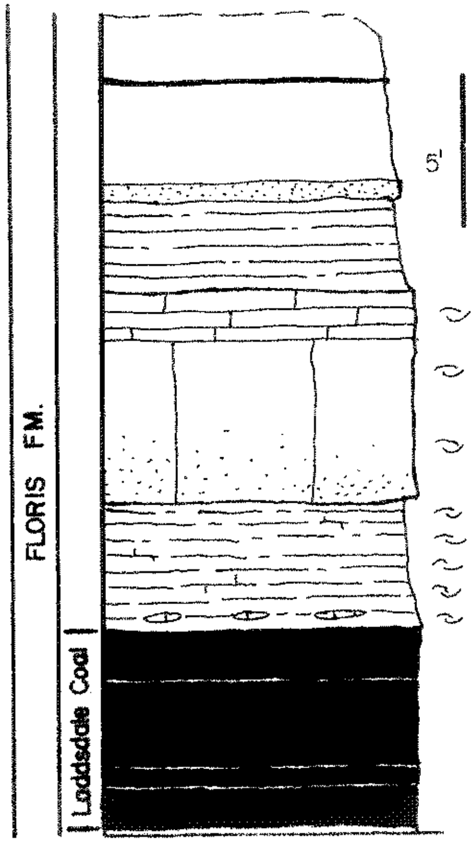
Ravn, R. L., J. W. Swade, M. R. Howes, J. L. Gregory, R. R. Anderson, and P. E. Van Dorpe, 1984, Stratigraphy of the Cherokee group and revision of Pennsylvanian stratigraphic nomenclature in Iowa: Iowa Geol. Surv. Tech. Info. Ser. #12, 76 p.

Sanderson, G. A. and R. R. West, 1981, Fusulinids from the Desmoinesian type area: GSA Abst. with Prog., v. 13, p. 545.

Shaver, R. H., 1984, Atokan series concepts with special reference to the Illinois Basin and Iowa: Oklahoma Geol. Surv. Bull., #136, p. 101-113.

Field Trip Stops and Discussions

STOP 1. NW 1/4, NE 1/4, Sec. 6, T.70 N., R.12 W., Davis County, roadcut.



Approx. 2' Mudstone-light gray, silty, ironstone, poorly exposed.

0.1' Shaley coal.

3.2' Mudstone-light gray green, weathered, slightly silty.

0.5' Sandstone-light gray, very fine grained, argillaceous, moderately cemented, carbonaceous debris.

3.8' Shale-grades from light gray brown upward to dark gray, silty, laminated.

6.7' Limestone-medium gray, slightly argillaceous, massive in the lower approx. 5', thin bedded above, with common brachiopods and crinoid debris. An irregular discontinuous band of chert nodules with sparse fossil debris is present appox. 3' above the lower contact.

5.1' Shale-medium gray, silty, calcareous to very calcareous with abundant brachiopods and crinoid debris. A band of limestone nodules occurs near the base of the unit.

6.8' Coal-banded, cleated with 1/2" to 1 1/2" light gray shale partings 2.1', 2.6', and 5.1' from the lower contact. Lower contact covered; exposed by digging.

0.4' Mudstone-medium brown gray, slightly silty with probable rooting. Covered.

DISCUSSION

The Laddsdale Coal at this exposure is exceptionally thick at 6.8 feet, although it is not known whether the single coal bed exposed here represents the entire Laddsdale Coal Member at this location. The Laddsdale Coal Member is extremely variable in thickness and number of coal seams throughout its extent. At its type section on Soap Creek approximately one mile south of STOP 1, the coal is split into five beds which range from a few inches to 2.7 feet thick. Similar variability was noted in an IGS core obtained from about one-half mile east of the type section, where four coals were recovered ranging from 1.2 to 4.1 feet thick. Separations between the coal seams range from a few inches to about 15 feet. Elsewhere in Iowa the Laddsdale consists of a single coal seam. The individual coal beds of the Laddsdale Coal Member are indistinguishable on the basis of their palynology suggesting that the Laddsdale Coal is the product of a single episode of peat deposition split by a series of clastic wedges of varying thickness. Deposition in an actively prograding deltaic environment is probably responsible for the variability that is typical of the Laddsdale Coal Member.

The coal is overlain by calcareous shale and limestone which were deposited during a local marine transgression. Influx of clastic sediment was temporarily halted with the result that calcareous algae and a marine fauna became established. Samples of the shale taken 1.5 to 2.0 feet below the contact with the massive limestone produced a stratigraphically useful conodont fauna. Among the significant Desmoinesian forms were Neognathodus medadultimus and several species of Idiognathodus. A paper by

Lambert (this guidebook) describes the conodont fauna in more detail. The limestone is overlain by nonmarine clastics including a rooted mudstone and coal streak.

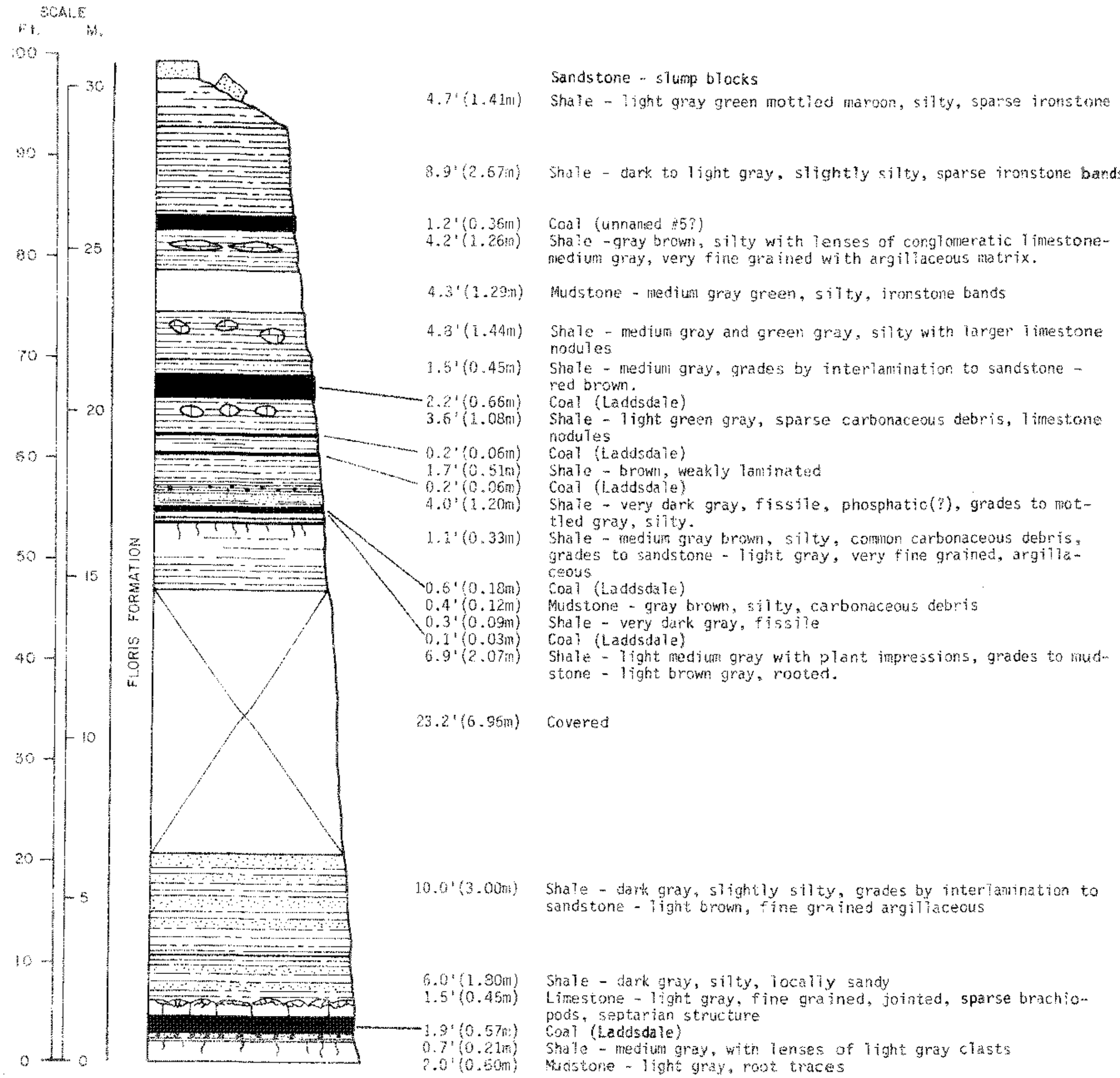
The thick coal and overlying marine units suggest deposition of the strata at STOP 1 in an environment which was stable and somewhat protected from clastic influx for a period of time. The shift to nonmarine clastic deposition probably resulted from a shift in the locus of deposition during progradation of the delta. This evolution of depositional environments suggests a lower delta plain to interdistributary bay setting.

STOP 1 is in an area of past mining activity. The ridge in which the outcrop is situated is extensively undermined as are the hills to the south. Most of the underground mines operated before 1920. A strip mine to the east in the floodplain of Soap Creek was reclaimed by an Abandoned Mine Lands project. All the mines in the vicinity probably mined the Laddsdale Coal. Remnants of the mining camp of Laddsdale, for which the coal was named, can be found along the railroad track west of Eldon.

Approximately 1/2 mile after crossing the Des Moines River the gravel road bends to the north away from the river. At this point, a prominent sandstone outcrop is visible in the opposite bank. This is one of the channel-filling sandstones which apparently originated in the upper part of the Floris Formation. The prominent ridge visible to the north is also composed largely of channel-filling sandstone. About one mile further north the gravel road passes the west end of the ridge. Here, outcrops of the cross-bedded sandstone are visible through the trees.

NOTES

STOP 2. NE 1/4, SE 1/4, Sec. 29, T. 72 N., R.13 W., Wapello County, road cut.



DISCUSSION

STOP 2 is at the type section of the Floris Formation. Units exposed at this locality range from the lowermost Laddsdale Coal bed, exposed north of U.S. 34 in a deep gully, to above a coal bed which may represent the unnamed coal ("#5") of the Floris Formation. The Carruthers Coal Member is not present at this locality. A previous description of this exposure lists a 2.0 foot thick coal bed in the interval which is now covered by U.S. 34.

The variability of the lower portion of the Floris Formation is clearly evident here. A total of five Laddsdale coals are exposed here ranging from a streak to 2.2 feet thick. The coal beds are separated by a few inches to approximately 25 feet of strata which varies from nonmarine clastics to marine shales and limestones.

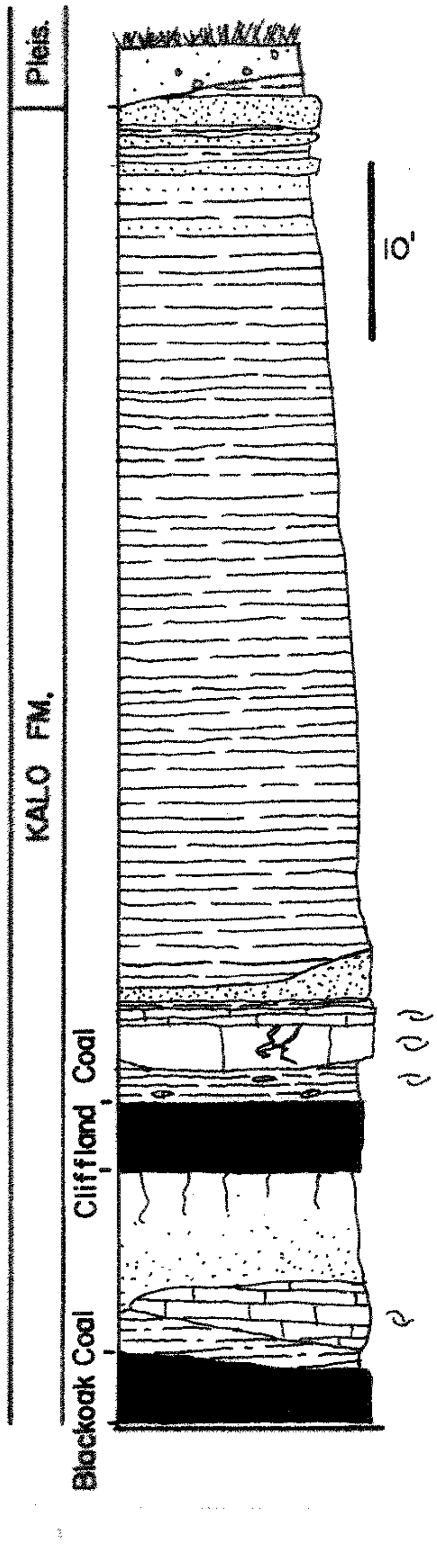
The lower coal bed is overlain by a sparsely fossiliferous limestone suggesting that the swamp was inundated by marine water and calcareous algae were able to become established. As at STOP 1, carbonate production was probably halted by progradation of deltaic sediments into an interdistributary bay. This was followed by several cycles consisting of peat accumulation, followed by marginal marine to marine deposition and a return to clastic deposition which concluded with development of the succeeding swamp. The limestone lenses near the top of the exposure appear conglomeratic due to infilling of fractures and solution channels by iron oxides possibly during weathering prior to deposition of the unnamed ("#5") coal.

The environment of deposition probably shifts from an interdistributary bay setting where the lowermost beds were deposited to a lower to transitional delta plain where the remainder of the strata were deposited.

Weathering of the strata exposed at STOP 2 has produced abundant dogtooth spar gypsum crystals which can be found scattered across the surface near the middle zone of limestone nodules. These probably result from an chemical interaction between the calcareous strata and very pyritic shales below the surface. The surrounding material is then eroded away leaving the gypsum behind as a lag deposit.

NOTES

STOP 3. SW 1/4, NW 1/4, Sec. 29, T.74 N., R.16 W., Mahaska County, abandoned strip mine.



60.0' Shale-medium dark gray, trace silt, waxy, laminated, with ironstone bands and pyrite lenses. The upper approx. 10' is interbedded with sandstone-light gray, laminated, iron stained, well indurated.

1.0' Sandstone-dark green gray, weathered orange brown, very fine grained, laminated. Lenticular masses up to 3' thick.

0.2' Shale-dark green brown, very weathered, granular with irregular vitrain bands.

2.7' Limestone-medium gray, very fine grained with sparse brachiopods, crinoid debris, and horn corals. Lower 2' is massive with septarian structure and fractures into angular pieces. The upper 0.7' is thin bedded and shaley.

0.7' Shale-very dark gray, laminated, carbonaceous, very calcareous, with small dark gray limestone nodules and fossils. Thickness varies 0.2' to 4.0'

3.9' Coal-laminated, cleated, weathered.

6.1' Mudstone-brown gray, very sandy at base decreasing upward, rooting disturbs laminations in upper half.

3.5' Limestone-medium gray, very fine grained, argillaceous, with sparse fossil debris and rare septarian structure.

2.1' Shale-very dark gray, fissile grades to laminated and silty.

4.0' Coal-cleated, banded, thickness varies 1.5' to 4.0'.

DISCUSSION

All strata exposed at STOP 3 are assigned to the Kalo Formation. The Blackoak Coal and Cliffland Coals were both mined (ca. 1971), although erosion has covered most exposures of the Blackoak Coal in the west end of the pit. A few remnants of the coal can be found near the base of the north wall. The Blackoak Coal is also exposed at the far east end of the strip pit where it is approximately four feet thick. Palynological analysis of this coal by R. A. Peppers of the Illinois State Geological Survey confirmed its identity and showed that it is equivalent to the Pope Creek Coal of Illinois. The very large limestone lens which forms the base of the strip pit at the west end overlies the coal. It has produced a few Atokan-age conodonts including the stratigraphically important form Neognathodus bothrops. An article by Lambert (this guidebook) describes the conodonts which were recovered in more detail. A mudstone with root casts in the upper part overlies the limestone and forms the seatrock for the Cliffland Coal.

The Cliffland Coal is exposed about fifteen feet above the floor of the strip pit. Its identity was also confirmed through palynological study by Peppers. The Cliffland Coal has been found to be approximately equivalent to the Rock Island No. 1 Coal of Illinois. The calcareous shale and limestone above the coal produced an abundant and diverse conodont fauna including a number of stratigraphically useful forms. The paper by Lambert on conodonts (this guidebook) summarizes the results of a preliminary study of the conodont faunas recovered from these units. The remainder of the exposure consists of 60 feet of shale which becomes coarser grained upward by the addition of sandstone beds.

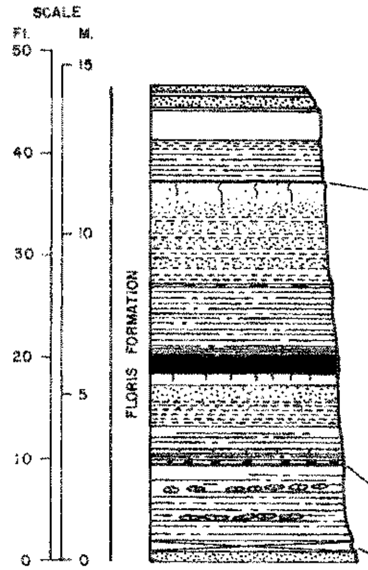
Ravn (1986) assigned the Cliffland to the Desmoinesian Series based on its assemblage of miospores. Preliminary results of conodont studies places the Atokan-Desmoinesian boundary between the Blackoak and Cliffland coals. For additional discussion of the problem see other papers included in this guidebook.

Deposition of the strata at STOP 3 probably occurred in a relatively stable lower delta plain to interdistributary bay environment in which marine environments were able to develop. The thick shale is the product of a delta system where progradation was gradual and uniform.

The exposures at STOP 3 are typical of the Kalo Formation. The coals are somewhat variable, but widely persistent throughout the area. The Cliffland and Blackoak coals have been identified in several nearby exposures and drill cores. The uniformity of the strata at this location is in sharp contrast to the rapid variation which is characteristic of the Floris Formation at STOP 2. The Kalo and Floris formations are products of different depositional regimes, hence the distinct contrast between them. The characteristics of these two units persist throughout south-central and central Iowa and therefore record regional geologic events.

NOTES

STOP 4. NW 1/4, NW 1/4, SE 1/4, Sec. 3, T.73 N., R.20 W., Lucas County, roadcut.



2.5'(0.75m)	Sandstone - light brown, fine grained, cross-laminated interbedded with shale - light gray, silty, laminated
2.8'(0.84m)	Mudstone - light green gray, mottled maroon and yellow trace silt
3.9'(1.17m)	Siltstone - light gray green mottled maroon and yellow, argillaceous; grades to shale - gray green, silty.
.05'(0.01m)	Smut
10.8'(3.24m)	Mudstone - light brown gray, silty, faint root traces; grades to sandstone - light brown, very fine grained, becomes interbedded with siltstone - light brown gray, argillaceous increases downward
0.5'(0.15m)	Shale - mottled light to dark gray, abundant phosphate nodules and laminae; ironstones at upper contact
6.1'(1.83m)	Shale - medium gray, mottled maroon, slightly silty with orange brown to maroon ironstones
0.7'(0.21m)	Shale - very dark gray, abundant small Lingula at base
1.4'(0.42m)	Coal (Carruthers) weathered, with shaley, pyritic band 2" above base
1.2'(0.48m)	Mudstone - light gray brown, silty, common carbonaceous debris
4.0'(1.20m)	Sandstone - light medium green, very fine grained, argillaceous; grades to siltstone - green, argillaceous.
2.4'(0.72m)	Shale - medium gray, slightly silty, grades to mudstone
0.6'(0.18m)	Limestone - light brown gray, slightly argillaceous, fossiliferous
1.1'(0.33m)	Shale - olive, silty, calcareous, fossiliferous, with phosphate nodules in lower 2"
.05'(0.01m)	Smut (Coal #5?)
7.2'(2.16m)	Shale - medium gray to green, silty, grades to mudstone with 2" to 3" nodular limestone.
1.1'(0.33m)	Covered
1.0'(0.30m)	Sandstone - brown, fine grained

DISCUSSION

The exposure at STOP 4 was designated as the type section of the Carruthers Coal. The strata exposed in this roadcut comprise most of the upper portion of the Floris Formation ranging from below a coal streak which is probably assignable to the unnamed coal ("#5") to just below the base of the overlying Swede Hollow Formation (a description of this section by Lugn, 1935, included the Whitebreast Coal and overlying strata near the top of the slope. These beds are now covered).

Below the Carruthers Coal, the exposure is very poor, but the nodular limestones and the thin fossiliferous limestone bed can still be seen at the south end of the roadcut. The thin phosphatic shale and coal streak could not be located.

The beds described below the Carruthers Coal are marginal marine to marine. The nodular limestones were previously correlated with the Seahorne Limestone of Illinois based on their position in relation to the "Wiley" Coal, but this correlation is no longer considered valid.

The Carruthers Coal can be identified throughout southern and central Iowa. It is variable in thickness, rarely exceeding 2.0 feet, and is typically poor in quality with an unusually high fusain and pyrite content. The Carruthers was previously correlated with the Wiley Coal of Illinois, but this correlation has been shown to be incorrect (see discussion elswhere in this guidebook) by palynological comparison. The fusain suggests oxidation from periodic exposure of the peat due to weathering. The Carruthers Coal varies from a few inches to 1.4 feet at this exposure.

The strata immediately overlying the Carruthers Coal range upward from an lingulid brachiopod-bearing shale to a thin shale with very abundant phosphate nodules (once described as "stink stones", the nodules have a distinct, unpleasant odor when struck or treated with hydrochloric acid). The shale is extensively mottled with maroon and includes abundant ironstones. Overlying the shale are two thin, coarsening upward sequences. The lower sequence ends with a coal streak which is widely traceable, both in the surface and subsurface.

The shale which immediately overlies the Carruthers Coal grades from a marginal marine Lingula-bearing shale to a marine phosphatic shale. The phosphate-bearing shale produced an extremely abundant and diverse conodont fauna.

Notable among the forms recovered was a single species of Gondolella and several significant forms of Idiognathodus and Neognathodus.

The upper part of the Floris Formation exposed here shows a comparatively greater marine influence than the older Cherokee strata, although fluvial-deltaic processes still dominate. In contrast to the lower part of the Floris Formation, the Carruthers Coal and associated strata are relatively widely traceable, suggesting a return to a more stable setting. The extensive mottling of the strata overlying the coal suggests oxidation which may have occurred during formation of the soil which supported the extensive swamps which produced the Whitebreast Coal, or possibly deposition in a site where periodic influxes of oxygenated water occurred (i. e. a well drained swamp).

NOTES

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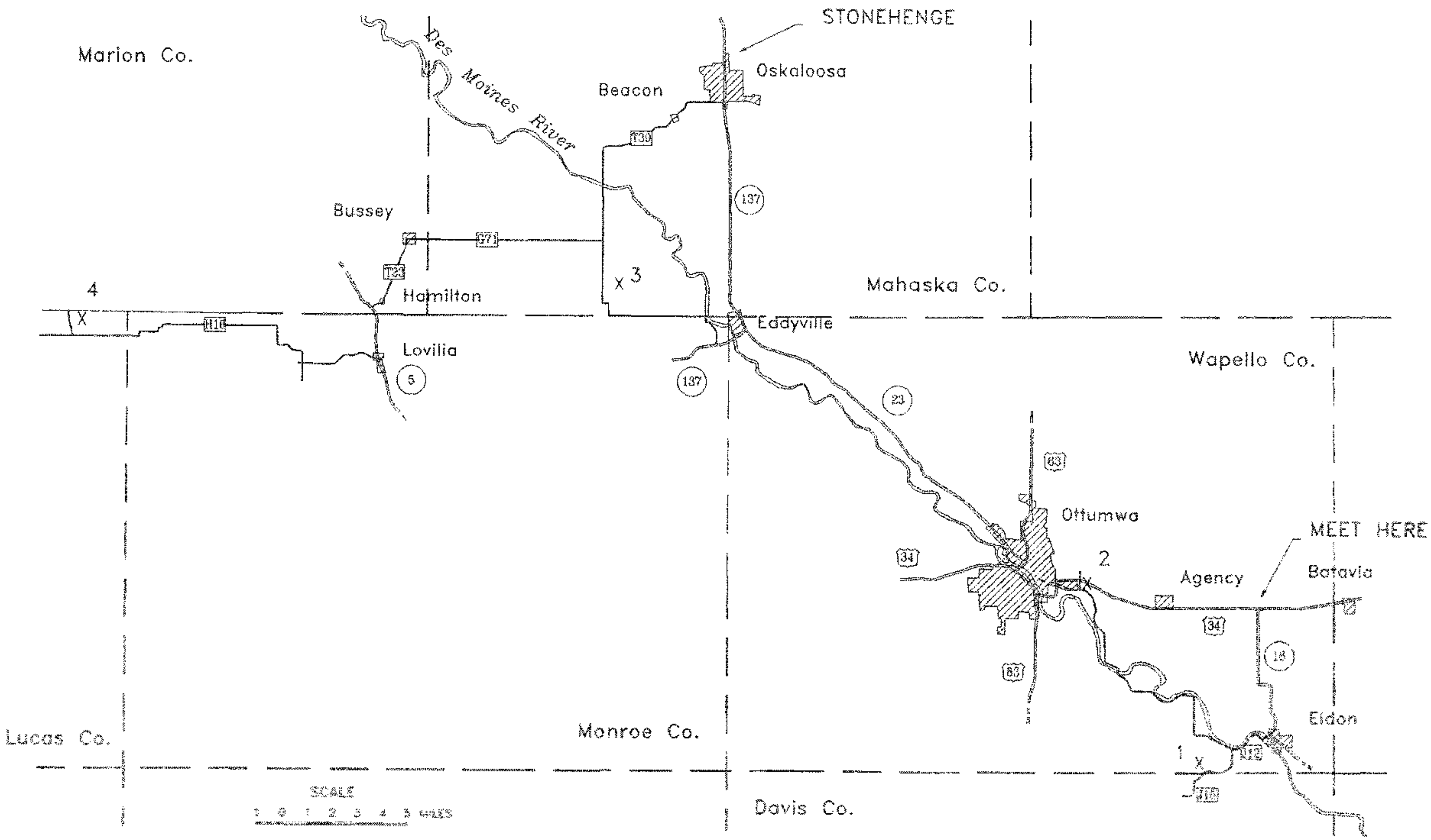
http://www.igsb.uiowa.edu/gsi/gsi.htm



STONEHENGE
Marion Co.
Des Moines River
Beacon
Oskaloosa
T30
137
Bussey
G71
T33
4
X
H10
Hamilton
x 3
Mahaska Co.
Eddyville
Lovilia
5
137
Wapello Co.
23
63
Ottumwa
MEET HERE
34
2
Agency
Batavia
34
16
63
Eidon
Lucas Co.
Monroe Co.
1
x
J12
Davis Co.
SCALE
MILES