Petrology, Petrography, Conodont Biostratigraphy and Correlation of an Unknown Pennsylvanian Cyclothem from an Outcrop in South-Central Iowa

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Purpose

The purpose of this project was to attempt correlation of an exposure of lenticular limestone and shale using biostratigraphy. The suspicion was that this outcrop was an exposure of the Elliot Ford Limestone member of the Floris Formation (Pope, 2012). Confirmation of this would enable designation of a new reference section for the Elliot Ford Limestone.

Abstract

An outcrop of lenticular limestone, exposed by road construction, about 9 km southwest of Knoxville, Iowa, in southwestern Marion County was discovered in 2001 during field work for the Iowa STATEMAP Project. Its stratigraphic position was believed to be somewhere in the Floris Formation, Cherokee Group, Moscovian (Desmoinesian) Stage, Middle Pennsylvanian Series, but its exact stratigraphic horizon was unknown. The exposed outcrop, from bottom to top, consists of limonitic light-gray mudstone below a 65 cm thick coal, overlain by 65 cm of limestone. The limestone is a very argillaceous skeletal wackestone to packstone with an abundant fauna of clams (mainly nuculids), gastropods including *Glabrocingulum, Palaeozygopleura, Shansiella* and *Bellerophon*, ostracodes, brachiopods *Desmoinesia muricata, Mesolobus mesolobus, Composita ovata, Crurithyris planoconvexa* and *Linoproductus.*sp., along with serpulopsid, fusulinid, tetrataxid and other small foraminifers. Other fossils include abundant carbonized wood fragments and macrospores, crinoid plates, fish teeth, echinoids, orthoconic nautiloid cephalopods, scolecodonts and conodonts. Glassy microspherules of undetermined origin were also found in the upper limestone. The limestone is overlain by several centimeters of blocky gray-green mudstone. A relatively abundant (140 P_1 elements/kg) conodont fauna was found near the top of the limestone. The conodonts include morphotypes of *Idiognathodus, Hindeodus, Adetognathus* and *Neognathodus* that are compatible with forms found in a lenticular limestone above the Carruthers Coal bed. This limestone, in Iowa, was named the Elliot Ford Limestone by J.P. Pope in 2012, and is the transgressive limestone of the third cyclothem in the Floris Formation (upper Tiawah of Oklahoma) below the major Verdigris cyclothem. We are also using topographic data in conjunction with nearby known outcrops to tentatively correlate this outcrop to the Elliot Ford Limestone Member of the Floris Formation.

Introduction

A Pennsylvanian cyclothem, in the Midcontinent Basin, is defined as a conformable succession of genetically related strata (an allostratigraphic unit) bounded by unconformities. They are the result of deposition during a single rise and fall of sea level, probably due to waning and waxing of glaciers in Gondwana. Heckel (1986, 2003) recognized major cyclothems as marine transgressive-regressive sequences centered on thin, non-sandy, black, phosphatic 'core' shales and bounded by unconformities (Figure 1). Heckel also recognized intermediate cyclothems as marine transgressive-regressive sequences centered on thin, gray to dark gray, conodont-rich core shales.

At its type section along the west side of Saylorville Lake in Polk County, Iowa, the Elliot Ford Limestone is interpreted as a transgressive limestone deposited in shallow open-marine conditions where limestone was only partially produced or preserved. It is possible that benthic limestone production was smothered by clastic influx, which dominates the rest of this cyclothem in the Floris Formation (Pope and Marshall 2009). The study outcrop in the Desmoinesian Stage (Figure 2) is located in southwestern Marion County, Iowa (Figures 3, 4).

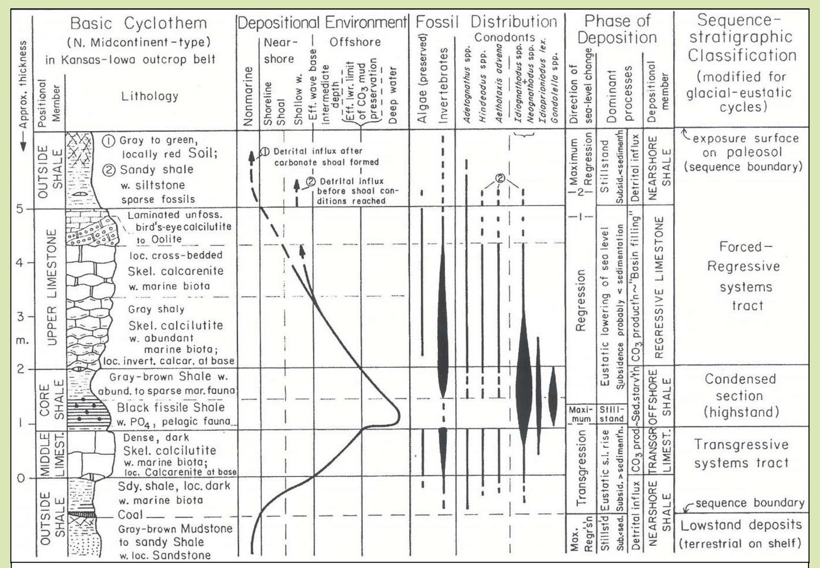


Figure 1 - Basic Midcontinent cyclothem characterizing major cycles of deposition across the Northern Midcontinent Shelf. (From Heckel, 1986)

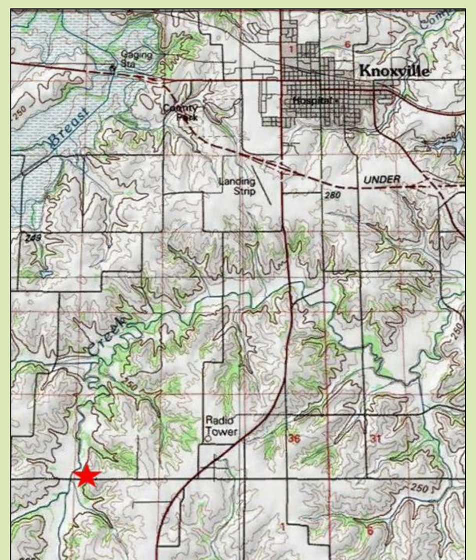


Figure 3 - Topographic map of outcrop area in relation to Knoxville, Iowa

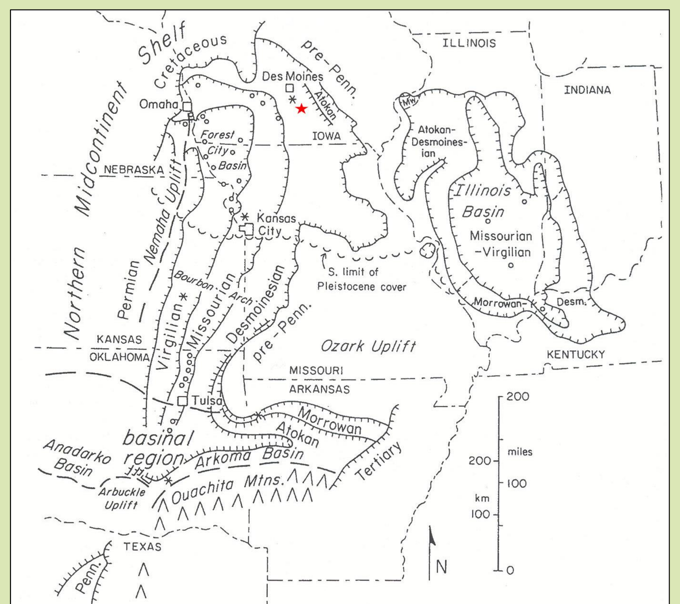


Figure 2 - Midcontinent Pennsylvanian outcrop belt (Modified from Heckel 1986); Red star denotes outcrop location

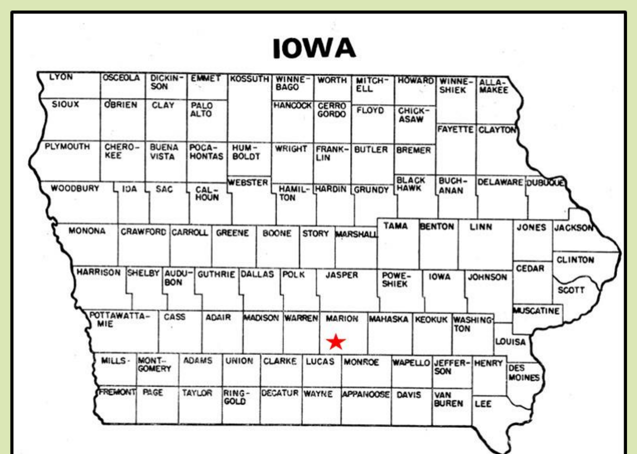
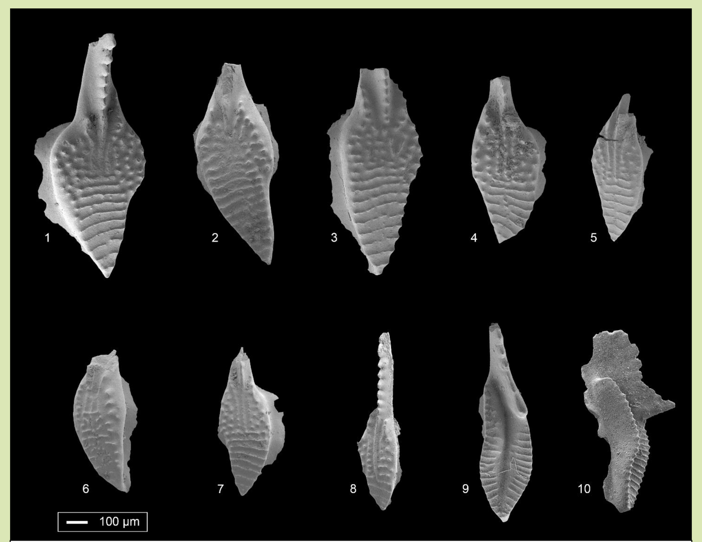


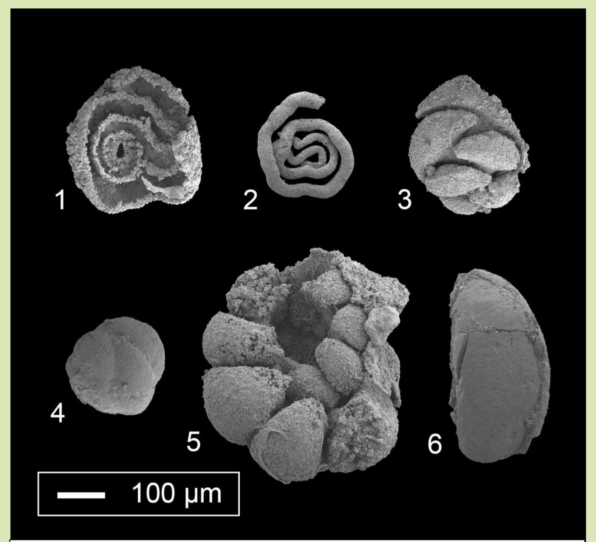
Figure 4 - Outcrop location in southwestern Marion County, Iowa

Methods

Shale and limestone samples were collected at measured intervals and wherever a lithologic change was noted. Each was collected using an entrenching tool and put into separate labeled plastic bags to avoid mixing of samples. The samples were then processed for macro and microfossils. Shales were oven dried and 1 kg of each dried sample was placed in kerosene. The kerosene was later decanted and replaced by hot water to break down the shale. 500 g limestone samples were dissolved in 10% acetic acid to enable collection of acid insoluble fossils (e.g., conodonts). Leftover limestone samples were thin-sectioned and examined under a polarizing microscope to identify fossils and determine depositional environments. Limestones were named using Dunham's carbonate classification system. Processed shale and limestone residues were then screened on 18, 120 and 230 mesh sieves, strained into individual towels for each sieve and oven dried. The weight of each sample was recorded after each step to enable extrapolation of data. The microfossils were picked from the dry 120 and 230 residue, and then mounted on SEM stubs for imaging. Once mounted, each stub was sputter coated with gold, then individually imaged using a JEOL JSM6400F scanning electron microscope (SEM).



Conodont P_1 elements *Idiognathodus* spp. (1 - 8); *Adetognathus* sp. (9 - 10)



Forams: encrusting 1; internal mold 2; *Globivalvulina*? 3, 4; endothyrid internal mold 5; ostracode 6

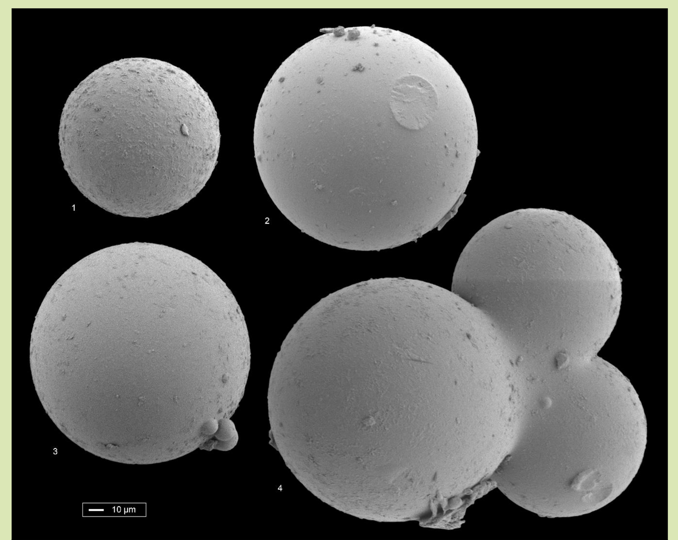
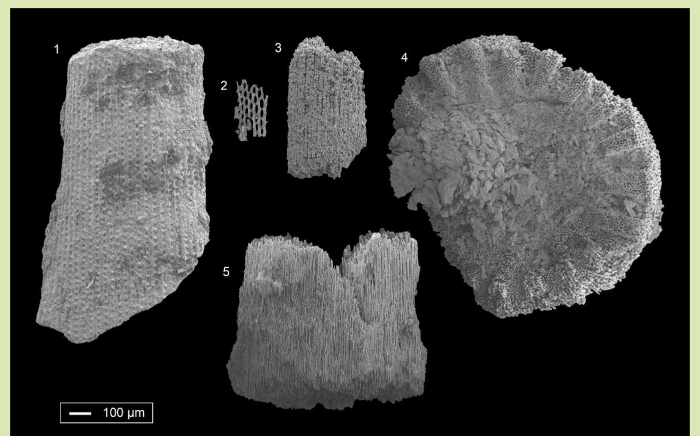
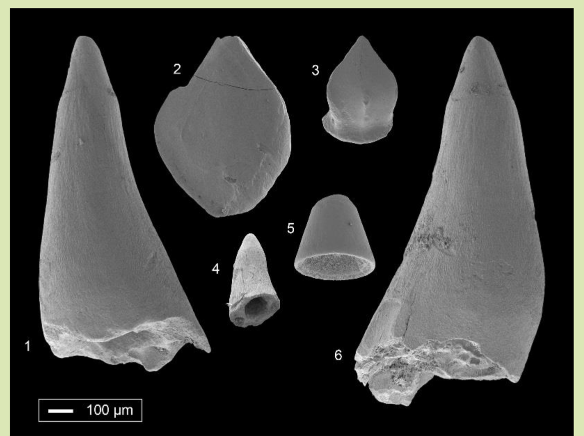


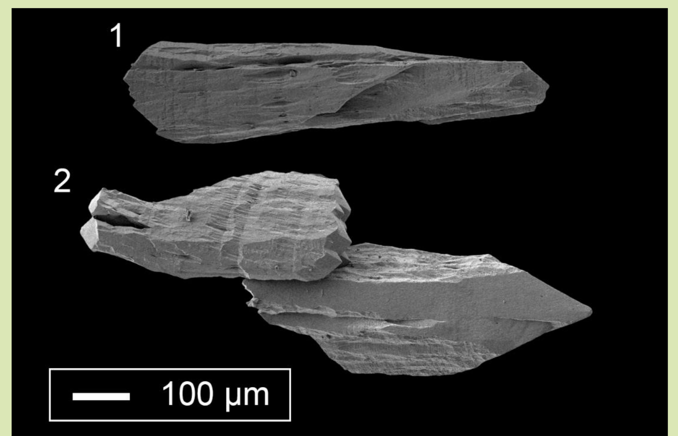
Figure 5 - Various plastic microspherules, initially thought to be microtektites, but determined to be contamination



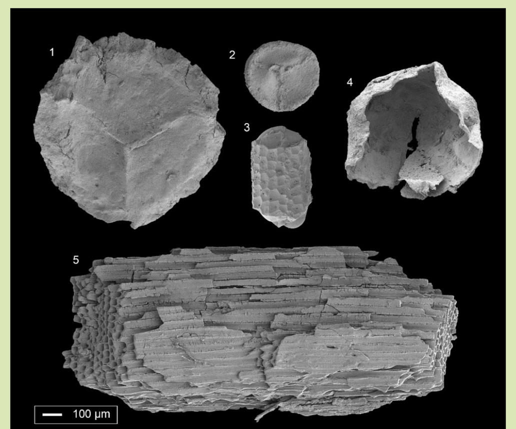
Fenestellid bryozoans 1, 2; echinoid spine 3; crinoid columnals 4, 5



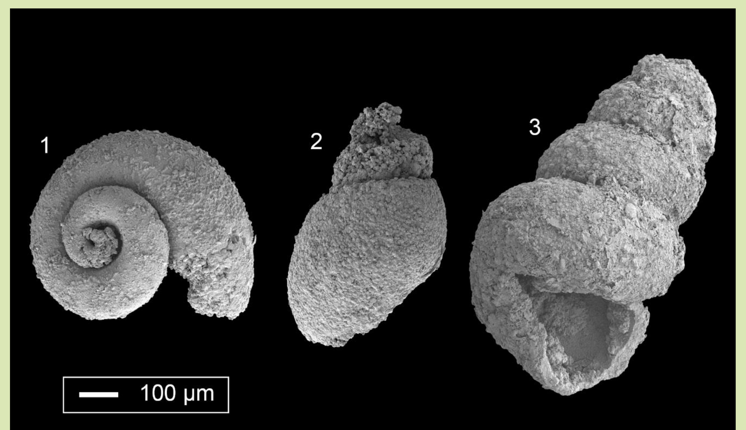
Bony fish teeth 1, 4, 5, 6; fish scales 2, 3



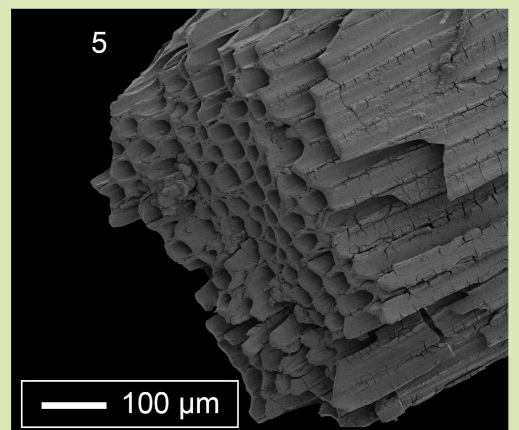
Authigenic quartz crystal fracture fill, base of upper limestone



Lycopod spores 1, 2, 4; carbonized wood 3, 5

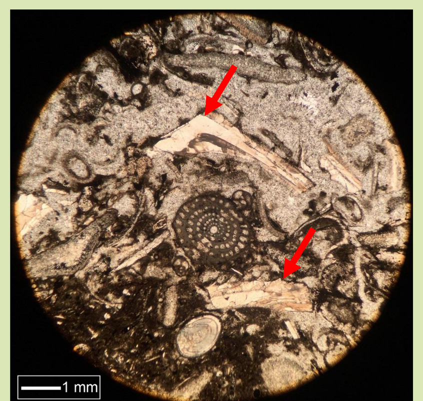


Pyrite internal molds of gastropods; 1 low-, 2 medium-, 3 high-spired

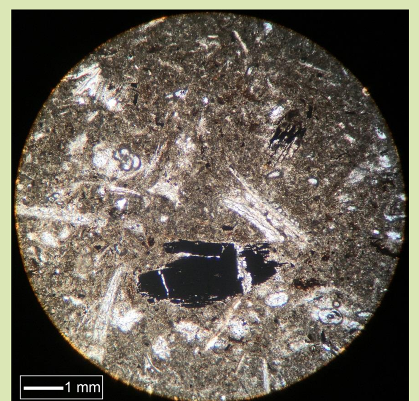


Close-up view: carbonized wood 5

Thin section: clam-rich skeletal packstone (PPL)



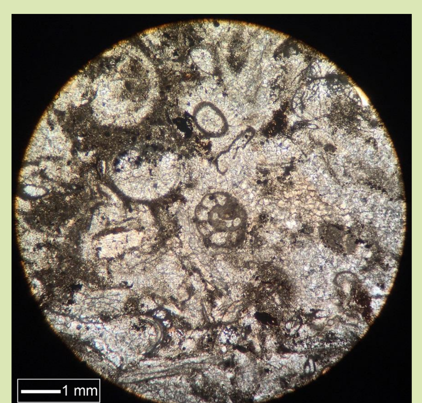
Thin section: fusulinid foram (center) with clam fragments-red arrows (PPL)



Thin section: carbonized wood (black, lower center) (PPL)

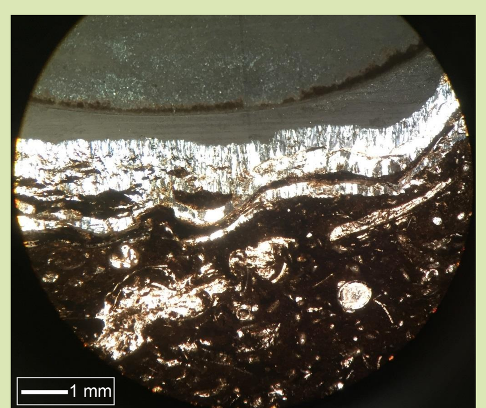
Thin section: skeletal packstone, crinoid columnal (center) (PPL)

Thin section: skeletal packstone, high spired gastropod (PPL)

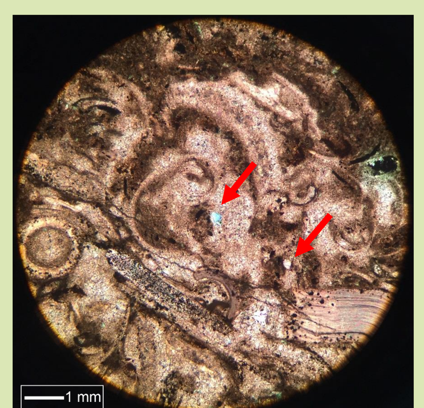


Thin section: small foramaminifer (center) (PPL)

Thin section: stained, brach spine (center), quartz silt (white dots) (PPL)



Thin section: fibrous quartz filling fractures in limestone (XPL)



Thin section: skeletal packstone with quartz silt (red arrows) (XPL)

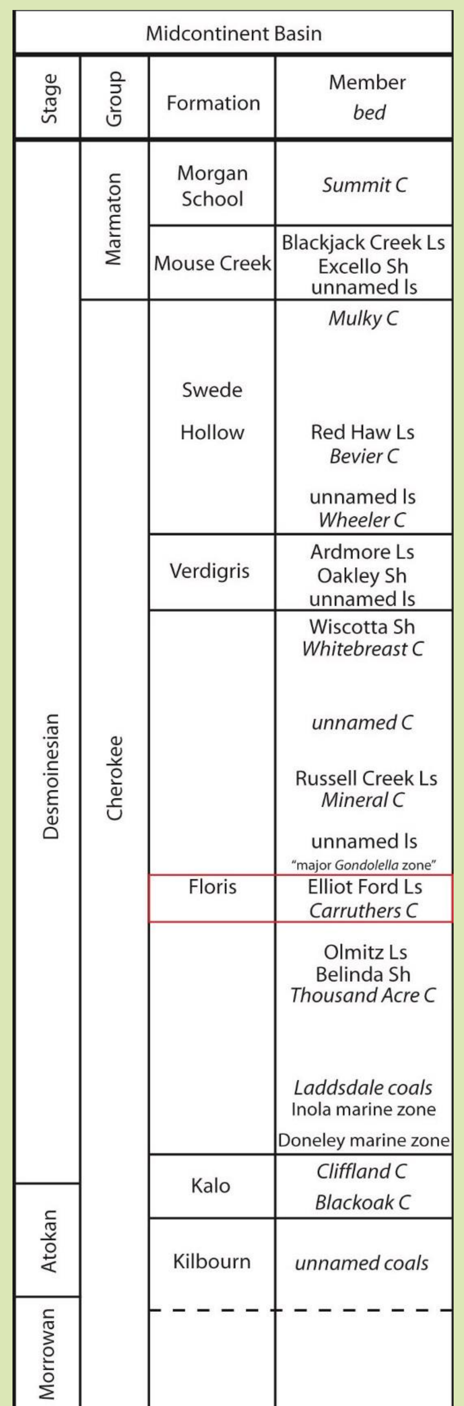


Figure 6 - Desmoinesian Stage of Iowa showing correlation of study outcrop (red box)

Lithology and Biostratigraphy

The investigated outcrop was somewhat poorly exposed and had an apparent dip of approximately 3° to the west. From top to bottom exposed strata consists of 6.5-8.0 m of poorly-exposed maroon mottled gray mudstone with goethite-hematite nodules. The lower 2 m of mudstone underlies a 1.25 cm thick coal seam, is yellow ochre mottled, with sandstone and siltstone lenses. The mudstone overlies 35 cm of light to medium gray, lenticular, argillaceous, skeletal wackestone to packstone. Thin sections of this limestone contain calcite-filled fractures. Below this is 5.0-10.0 cm of strata that varied from extremely argillaceous, medium gray skeletal wackestone with abundant shale partings to a medium gray, calcareous shale with skeletal wackestone nodules. The lower 30 cm of limestone is an argillaceous, medium gray skeletal wackestone. Thin sections of this limestone contain fibrous quartz-filled fractures. The entire limestone occurs as a lens at least 15 m across. Strata horizontally adjacent to the limestone lens is mainly relatively unfossiliferous light to medium gray shale and mudstone. The limestone overlies 2.5-5.0 cm of pyritic and limonitic medium gray shale with abundant melanterite and gypsum crystals. This layer grades downward into 65.0 cm of coal with scattered calcite-filled fractures. Below the coal is 2.5-5.0 cm of limonitic, rooted, light to medium gray mudstone, exposed by trenching.

Biostratigraphic investigation, using thin sections and fossils collected on the outcrop, revealed that the upper 35 cm of limestone contains an abundant fauna of clams (mainly nuculids); gastropods including *Glabrocingulum, Palaeozygopleura, Shansiella* and *Bellerophon*; ostracodes; brachiopods *Desmoinesia muricata, Mesolobus mesolobus, Composita ovata, Crurithyris planoconvexa* and *Linoproductus.* sp.; along with serpulopsid, fusulinid, tetrataxid and other small foraminifers. Other fossils include abundant carbonized wood fragments, macrospores, crinoid plates, fish teeth, echinoids, orthoconic nautiloid cephalopods, scolecodonts and shallow water conodonts *Idiognathodus, Hindeodus, Adetognathus* and *Neognathodus.* Conodont abundances in the center of the upper limestone ranged upward to 140 P_1 elements/kg. The shale zone in the middle of the limestone had a similar, but less abundant macrofauna, with no conodonts recovered. The lower limestone had an even less abundant macrofauna with no conodonts recovered.

In the middle of the upper 35 cm of limestone, microspherules (Figure 5) ranging from 2-150 μm were found while picking acid-insoluble microfossil containing residues, from the 120 and 230 mesh sieves. Most of the microspherules have a clear glassy luster, but some are cloudy and appear frosted. Some of the microspherules were fused together, others were "cemented" together, while others contained spherical vesicles. Initial interpretation of the spherules was that they were glassy micro-tektites. Further testing of the microspherules revealed they were not glassy. When subjected to heat the microspherules melted and a burning-plastic odor resulted. The microspherules have since been interpreted as plastic contamination either from the outcrop, plastic collection bags or plastic containers used for dissolving the limestone.

Interpretations of Depositional Environments

The lower light gray mudstone is interpreted as being a paleosol formed during sea level lowstand. Carbon traces are from roots of plants which grew on the soil during ponding of fresh water ahead of sea level rise. The top of the paleosol has considerable relief (over 9 m) and dips to the west in what may be a paleovalley. The coal formed from peat deposited in a coastal swamp during early transgression. Later during transgression, the peat swamp was flooded by marine water, seen as deposition of the thin shale above the coal. As sea level continued to rise argillaceous limestone was deposited in a nearshore marine environment. This would explain the abundance of macrospores and carbonized wood debris. The shaly zone in the middle of the limestone may represent a minor clastic influx event. The conodont-rich zone in the middle of the upper limestone probably represents maximum transgression with sea level remaining at a constant level (stillstand) for an extended period of time. This allowed pelagic organism (e.g., conodonts) to concentrate in the sediment due to a slowdown in sediment accumulation. The upper few centimeters of the limestone may represent a regression, followed by shale deposition and finally another paleosol development during the next sea level lowstand.

The limestone was formed by benthic calcite-secreting organisms (e.g., algae, clams, snails). The limestone is lenticular in development, partially because of clastic influx inhibiting benthic organism growth and partially because the benthic organisms could not colonize the entire ocean floor. The latter was because the organisms were trying to grow on top of decaying organic material, which may have produced low oxygen and perhaps acidic bottom water. Where the bottom was more oxygenated the benthic fauna and flora flourished, creating lime mud that later became limestone.

Correlation

Macrofossils (e.g., clams, snails, brachiopods, fusulinid foraminifers), microfossils (e.g., small foraminifers) and conodonts (especially species of *Idiognathodus*) found in the limestone are compatible with those that are found in the Elliot Ford Limestone at its type section. The elevation of the study outcrop is nearly the same as other outcrops of the Elliot Ford Limestone found within several miles of the study outcrop. The study outcrop (Figure 6, 7, 8) is also at an elevation below the documented Verdigris Formation and above the elevation of the Belinda Shale.

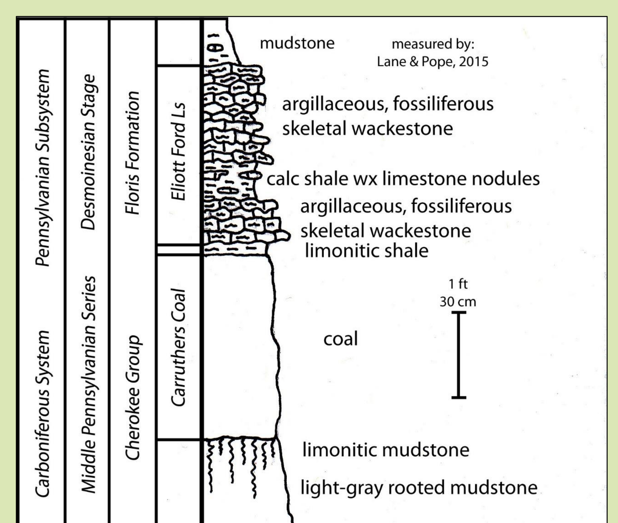


Figure 7 - Stratigraphic column of study outcrop

Figure 8 - Photograph of study outcrop

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Acknowledgements

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