RETURN TO MORGAN QUARRY:

A glimpse of unique Quaternary sediments of the Iowan Surface, middle Devonian strata, and newly exposed Silurian dolomite

edited by
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Geological Society of Iowa

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2018 aerial photo of the Morgan Quarry. Recent expansion operations to the south is located in the red polygon. The recent pit dug to access the Silurian Hopkinton Fm. is in the red box.

Cover Image

Iowan Erosion Surface till leaking into crevices formed in the Devonian Solon and Davenport members along the west wall of the Morgan quarry. (photo by Ryan Clark)

INTRODUCTION

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The 2019 Iowa Academy of Science (IAS) annual meeting is at the University of Northern Iowa in Cedar Falls, Iowa. Again this year, the meeting is followed by a field trip organized under the auspices of the Geological Society of Iowa (GSI). The GSI may not be an official membership-granting organization, but plans are in the works to partner with the IAS to reestablish the GSI into a more formal entity with the hopes of bringing it back to its former glory. We thank the GSI 'membership' for their continued support throughout this transitional period.

The emphasis of this year's field trip to the Morgan Quarry is to examine exposures provided by the recent expansion of quarry operations toward the south, as well as downward. Current efforts to expand the quarry have exposed Quaternary deposits not previously seen and will be the focus of study to build on the current understanding of the formational history of the Iowan Erosional Surface landform region. The recent decision by BMC to deepen the Morgan quarry in order to exploit the Silurian bedrock for aggregate resources has led to a new pit that will allow us to access the Hopkinton Formation for the first time at this location. Information in this guidebook regarding Devonian stratigraphy was gleaned from GSI Guidebook No. 75, which remains pertinent.

ACKNOWLEDGMENTS

Our gracious host today is Basic Materials Corporation, L.C. (BMC), owner/operator of the Morgan Quarry located in Waterloo, Iowa. They have opened their doors to countless groups of interested people, from amateur rock hounds to accomplished research geologists, highlighted annually with the "Sunday at the Quarry" events, which rotate between Morgan and Raymond quarries. Everyone that is welcomed into one of BMC's quarries leaves with a greater appreciation for the natural beauty of the geology and an understanding that "If it can't be grown, it has to be mined".

Special thanks goes to BMC's geologist, Sherman Lundy, for helping facilitate this event. Without his support and cooperation, this GSI field trip would lack the educational value we desire to offer our participants.

Finally we ask the field trip participants to use common sense and conduct themselves in a manner that will ensure their safety as well as the safety of those around them, so we can hope to maintain a positive relationship with BMC for years to come.

QUATERNARY GEOLOGY OF THE CEDAR FALLS/WATERLOO AREA

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THE IOWAN '*EROSION*' SURFACE

The Cedar Falls/Waterloo area lies in the heart of one of Iowa's largest landform regions: the Iowan Surface (Fig. 1). The topography of this region contains gently rolling landscape and broad open vistas (Prior, 1991). Earlier workers thought the origin of this landscape region was due to an "Iowan Glacier" that invaded the area sometime between the Illinoian and Wisconsinan glacial periods. The "Iowan" was later assigned to the earliest substage of the Wisconsinan. Because of the lack of exposures in this area, the age and origin of this supposed glacial drift was debated for many years. Robert Ruhe, 1960s, and his coworkers undertook a detailed investigation of these sediments utilizing drilling and radiocarbon dating. They determined that the so-called Iowan drift did not exist; there had not been an Iowan Glacier at all (Ruhe, 1969). Instead, they showed that the landscape and sediments of this part of the state were actually the result of severe erosion. The Iowan Erosion Surface (IES) or simply Iowan Surface is an extensive erosion surface complex cut into Pre-Illinoian-age glacial deposits (Hallberg *et al*., 1978).

The IES is a complex Pre-Illinoian landscape possessing integrated drainage networks reshaped by a combination of Wisconsinian periglacial, fluvial, and eolian processes whose intensities varied across the landscape (Mason, 2015). The approximate time range for these landscape modifications took place between 21,000 and 16,500 years ago during the coldest part of the Wisconsinan. Investigations involving analysis of fossil pollen, plant macrofossils, small mammals, insects, and mollusks at various sites in Iowa and adjacent states provide evidence that this region had a cold climate with open tundra conditions (Baker *et al*., 1986, 1989, 1991). Geomorphic processes in this region led to the formation of distinctive erosional and depositional landscape modifications, reworking Pre-Illinoian glacial landforms. One of these landscape modifications led to a residual lag deposit or stone line/stone zone (Walters, 1994; Matzke et al., 2013). The processes that led to the development of this surface appear to have been a combination of cryogenic, permafrost, and active zone erosive, slope wash, processes (Matzke et al., 2013; Mason, 2015). Another prominent IES landform include isolated Paha characteristically long elliptical hills consisting of thick loess deposits frequently underlain by basal paleosols atop Pre-Illinoian till (Mason, 2015). Iowan Paha follow a northwest to southeast trend and currently are interpreted as areas of thick loess deposition downwind of locally controlled obstacles to eolian transport (i.e. short valley segments with steep bedrock slopes (Mason, 2015). A third attribute of the IES are a variety of low-relief eolian sand deposits, dunes, and sand 'stringers' that generally follow a similar northwest to southeast trend (Zanner, 1999).

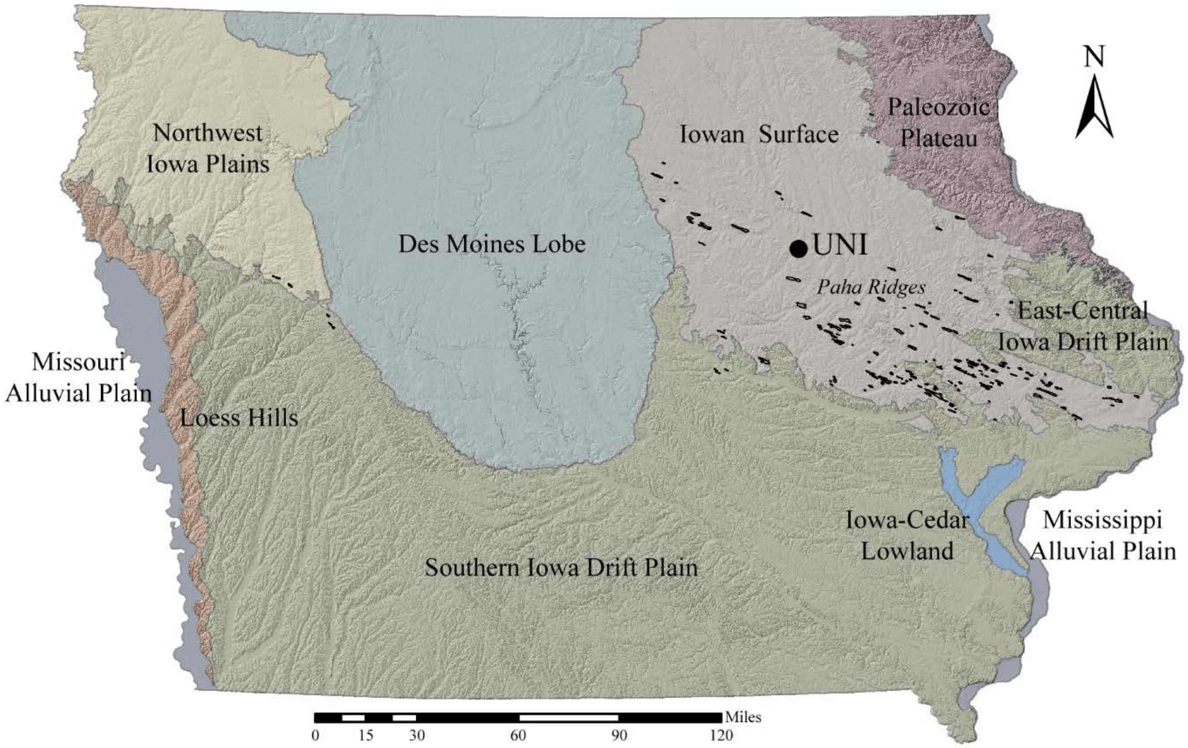

Figure 1. Dot identifies fieldtrip location within the Landform Regions of Iowa (after Prior, 1991).

The Cedar Valley

Although the term Cedar Valley refers to political boundaries, there is, in fact, a geomorphological Cedar Valley. The Cedar Valley is a result of glacial, permafrost, fluvial, and eolian processes occurring during late Pleistocene to Holocene time. The stage was set with a blanket of Pre-Illinoian till over Devonian-age bedrock sometime between 2 million and about 500,000 years ago. We know there must have been at least two and as many as eight episodes of continental glacial activity during Pre-Illinoian time. The last ice sheet exited the area by 500,000 years ago. The ancestral Cedar River probably began cutting its valley shortly after the last ice sheet left and perhaps was in existence even in between these early episodes of continental glacial activity.

The most recent Pleistocene glacier, the Wisconsinan ice sheet, covered only the north-central part of the state and extended as far south as where the city of Des Moines sits today. This lobe of ice, known as the Des Moines Lobe (Fig. 1), lay to the north and west of the Cedar Falls/Waterloo area, and must have shed enormous volumes of meltwater to the Cedar River. The Cedar developed into a typical glacial meltwater stream, with numerous braided channels and huge amounts of glacially derived sediments. After the Des Moines Lobe retreated from Iowa, these large volumes of glacial meltwater no longer influenced the development of the Cedar River Valley. The river system became smaller and the large valley it had cut was now out of proportion to the size of the river. In fact, the Cedar River is an under fit stream, a stream that appears too small to have eroded the valley in which it now flows.

In more recent times, but perhaps starting as early as about 22,000 years ago, strong winds blowing along the abandoned Pleistocene floodplains of the Cedar River created dunes and sand sheets in and adjacent to the Cedar Valley. All of these eolian features have a northwest-southeast orientation and they are mostly restricted to the edges of the Cedar Valley, but they also may be deposited on the surrounding glacial landscape.

Quaternary Geology of Morgan Quarry

Pre-Illinoian sediment up to 30 m thick appear on the south side of the Morgan Quarry. Sections also exist on the west and north sides, but they are not as thick. The Quaternary sediment unconformably lies above the Solon Member of the Devonian Little Cedar Formation. The surface of the Solon Member contains several places where striations and glacial polish are present on the surface of the limestone bedrock. The striations show an azimuth of 290-294 degrees, indicating that the earliest Pre-Illinoian ice sheet in this area came from a westerly-northwesterly direction.

Examination of the sediments suggests there are a series Pre-Illinoian events/units present (Fig. 2). The lowest unit (Unit 1) varies from 1 to 3 m thick and directly overlies the Solon Member (Middle Devonian ~390Ma) creating a roughly 290Ma disconformity. Unit 1 has characteristics that lead to an interpretation of a glaciolacustrine deposit. Unit 1 is characteristically blue-gray, calcareous, clay (~95% clay) with minor course fragments/small pebbles. Spruce (?) wood fragments with some larger pieces up to 30 cm long are present at the top of this dark layer. The initial interpretation of Unit 2 is a partial geosol: ~80 cm thick, reddish-brown, well-developed sub angular blocky structure, with sharp contacts below and above. The majority of the outcrop on Morgan Quarry's southern extent consists of IES sediments (Unit 3) possibly of glaciofluvial origin. Unit 3 varies in thickness from 4 to 14 m and forms a moderate slope with a distinctive color change to orangish-yellow. These sediments are primarily sand-sized clasts (fine to coarse) with stratification/bedding commonly found in alluvial environments and areas of iron and manganese concentrations are present. Unit 4 needs more investigation as it may either be till (dark brown, mixture of sand and clay with organics and course fragments) or mine fill material.

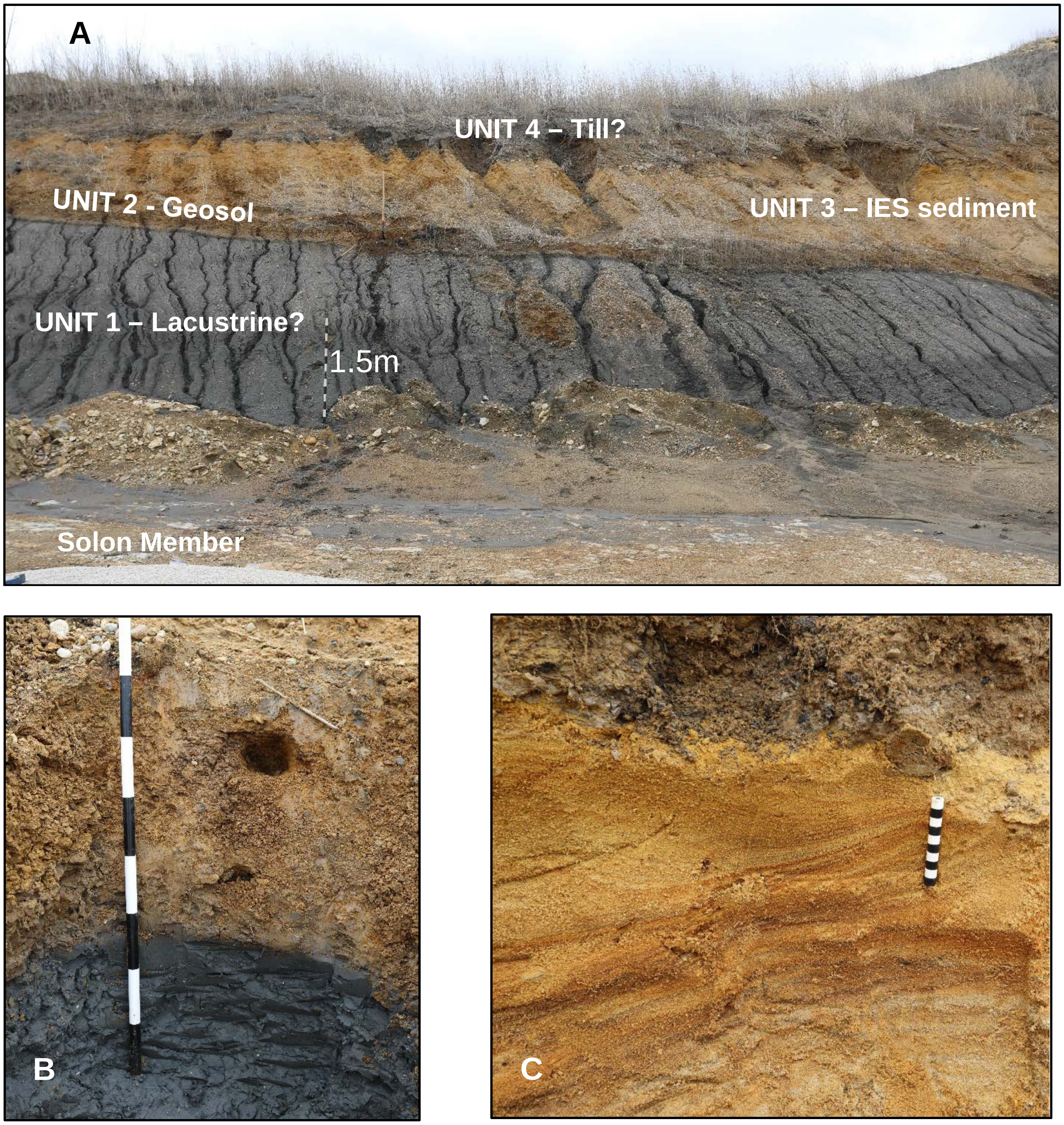

Figure 2. Photo A is an overview of the southeast facing extent of Morgan Quarry. Photo B shows the contact between Units 1 and 2. Photo C is shows the contact between Units 3 and 4.

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BEDROCK STRATIGRAPHY OF THE MORGAN QUARRY: Devonian Solon Member – Silurian Hopkinton Formation

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with contributions by:
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INTRODUCTION

The Waterloo/Cedar Falls area lies directly within the area termed by retired Iowa Geological Survey (IGS) geologists Brian Witzke and Bill Bunker as the "Devonian Iowa Basin". During the middle Devonian, this region of the midcontinent was not a deep abyss, but rather a dynamic continental shelf environment where thick marine deposits piled up as the basin subsided. This is why we see repeated sequences of carbonate rock units (limestone and dolomite) rather than deep water shale units. The repeated marine sequences, also known as "cyclothems", are quite subtle and almost invisible to the untrained eye. However, with the help of microscopic fossils known as conodonts, at least four distinct cyclothems were identified within the Cedar Valley Group (Shell Rock, Lithograph City, Coralville, and Little Cedar formations). Today's trip into the Morgan Quarry will illustrate the lowermost cyclothem, the Little Cedar Formation, and its encompassing members; the Davenport, Spring Grove, and Kenwood (see strat column on back cover).

REGIONAL DEVONIAN STRATIGRAPHY

Cedar Valley Group – Little Cedar Formation

The Little Cedar Formation (Fig. 3) includes lower Cedar Valley strata which are bounded below by the Wapsipinicon Group (or Ordovician-Silurian rocks where the Wapsipinicon is absent) and above by the Coralville Formation. The type locality is at the Chickasaw Park Quarry (Witzke *et al*., 1988) adjacent to the Little Cedar River in southwestern Chickasaw County, Iowa; this locality exposes one of the most complete sections (17 m) of the formation in northern Iowa. The Little Cedar Formation ranges from 15 to 37 m in thickness; it is thinnest in southeastern Iowa and thickest in northern and central Iowa. The Coralville overlies a disconformity or discontinuity surface at the top of the Little Cedar Formation at most localities. However, the Lithograph City Formation is locally incised into the Little Cedar Formation in parts of Johnson County and the Sweetland Creek Shale overlies the formation at a few localities in southeastern Iowa. The Little Cedar Formation is interpreted to have been deposited during a large-scale T-R cycle (part of cycle IIa of Johnson *et al*., 1985), the Taghanic Onlap (Johnson, 1970). The formation is subdivided into three to four members in northern and central Iowa (in ascending order, Bassett, Chickasaw Shale, Eagle Center, and Hinkle) and two members in southeastern Iowa (Solon and Rapid). Subsequent discussion of the constituent members defines lithologic variations within the formation.

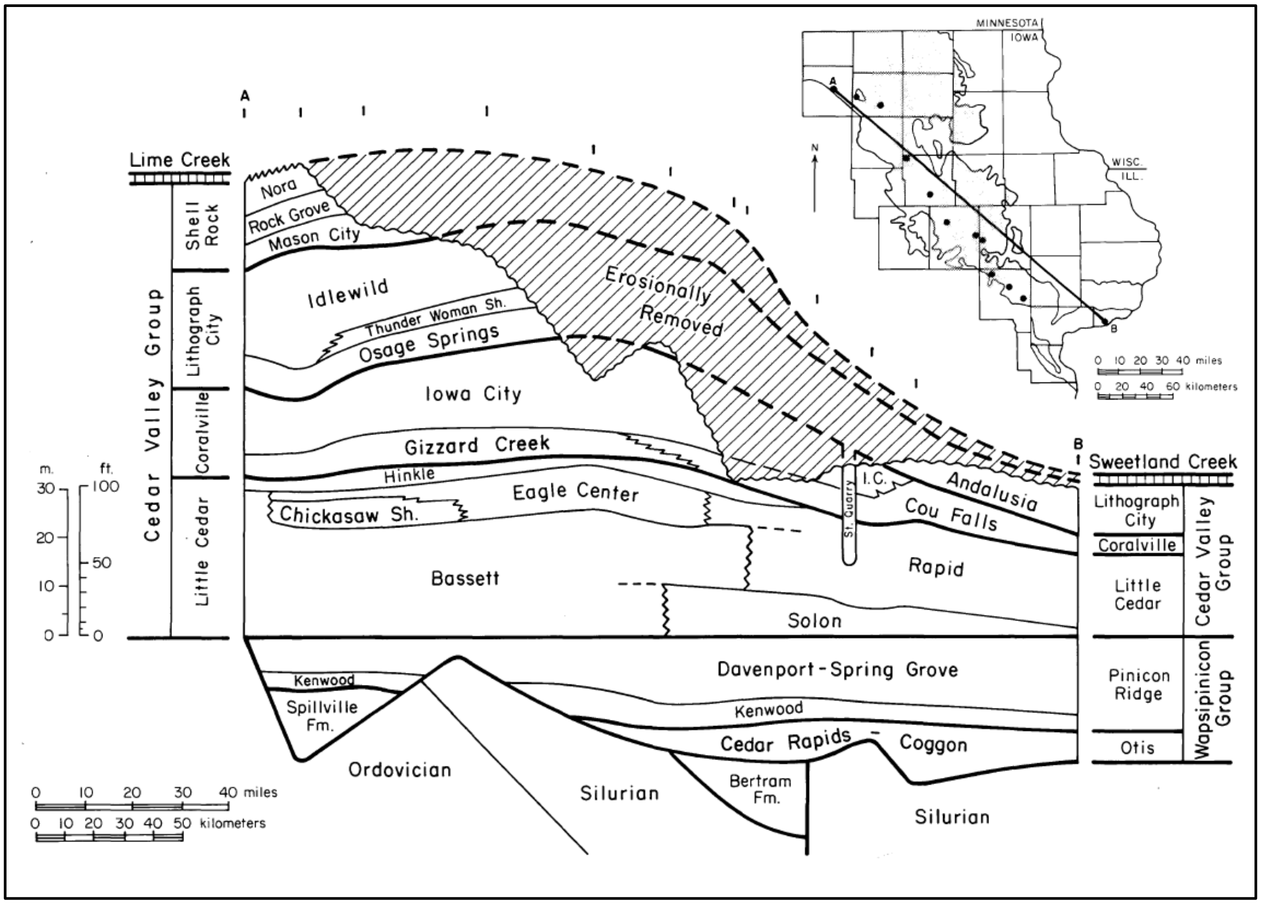

Figure 3. Generalized stratigraphic cross-section from north-central to extreme east-central Iowa, showing interpreted stratigraphic relationships of the various units of the Wapsipinicon and Cedar Valley groups (from Witzke *et al*., 1988).

Solon Member. The Solon Member (Fig. 3) is dominated by fine skeletal muddy calcarenite (biomicrite and some biosparite) with scattered shaly or carbonaceous partings (Kettenbrink, 1973). Argillaceous calcilutite is present, especially near the northern limits of the member. Hardgrounds are developed locally. A thin sandy limestone is commonly present at the base; this sandy interval locally includes sandstone facies (Hoing Sandstone) in parts of northern Missouri and western Illinois (Collinson and Atherton, 1975; Tissue, 1977). The basal contact is disconformable (Fig. 4), but the upper contact with the Rapid Member is variably gradational or sharp (locally a burrowed discontinuity surface or hardground). The Solon Member is limited geographically to areas of east-central and southeastern Iowa and adjacent areas of northern Missouri and Illinois. The member varies from 1.5 to 12 m in thickness and is thinnest to the southeast. It generally thickens to the north, and skeletal calcarenites of the Solon are replaced by argillaceous dolomites of the lower Bassett Member in that direction.

<u>Wapsipinicon Group – Pinicon Ridge Formation</u>

The name Pinicon Ridge Formation was first proposed by Witzke *et al*. in 1988 for the unfossiliferous Devonian rock sequence overlying the Otis or Spillville formations and disconformably underlying the fossiliferous Cedar Valley Group. The type locality is designated at Pinicon Ridge Park in northwestern Linn County, Iowa, in the historic type area of the Wapsipinicon Group. The formation consists of three previously named members, in ascending order, the Kenwood, Spring Grove, and Davenport. The Pinicon Ridge Formation overlaps the Spillville and Otis edges to overstep an eroded surface of Ordovician and Silurian rocks in parts of central and southern Iowa, northern Missouri, and western Illinois. It partially buries paleotopographic ridges or paleo-escarpments of resistant Silurian carbonate rock (Hardin-Bremer, Washington-Louisa, and Pike-Schuyler highs). The Pinicon Ridge ranges from about 20 to 40 m in thickness across most of Iowa (with a maximum thickness of 57 m in southeastern Iowa) and varies from 8 to 13 m in north-eastern Iowa. The formation is dominated by unfossiliferous carbonate (variably shaly, laminated, or brecciated), but gypsum and anhydrite, occasionally of economic importance, are widespread in central and southeastern Iowa. Its stratigraphic position suggests an early Givetian age (Upper *ensensis*-Lower *varcus* sub-zones), although the magnitude of the disconformity at the top of the sequence is unknown. Erosional relief at the top of the formation is difficult to evaluate because of extensive brecciation, but is not known to exceed 40 cm. Constituent members of the Pinicon Ridge Formation are lithologically distinct, as discussed below.

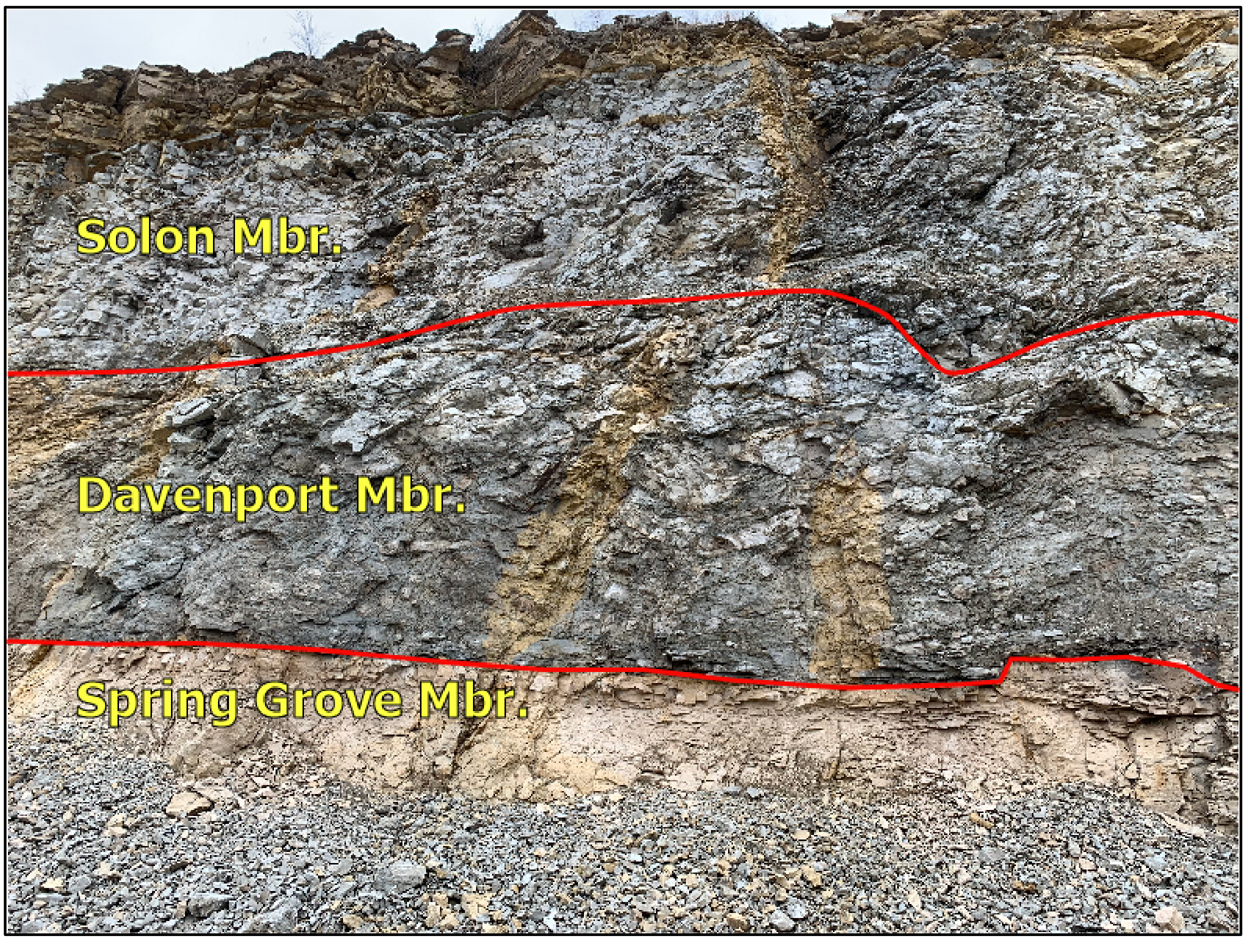

Figure 4. Bedrock section seen at the Morgan Quarry showing the irregular, unconformable contact between the basal Cedar Valley Group (Solon Member) and the upper Wapsipinicon Group (Davenport Member). (photo by Ryan Clark)

Davenport Member. The Davenport Member consists primarily of dense limestone (commonly "sublithographic" and stylolitic), dolomitic limestone, and dolomite. The limestones are laminated in part, and pelletal, oolitic, intraclastic, and "birdseye" fabrics are locally present. The Davenport is generally unfossiliferous, although ostracodes, burrows and stromatolites have been noted. Shale lenses and partings are scattered, and sandy to argillaceous carbonate is present in some beds and fracture fills, especially in the upper part. The member is extensively brecciated across most of its extent, but becomes less brecciated eastward into Illinois. The breccias are composed of angular clasts and blocks of carbonate in a matrix of limestone or dolomite (Fig. 5). Breccia clasts are composed predominantly of dense limestone, in part laminated, which are indistinguishable from many non-brecciated limestone lithologies of the Davenport. However, clasts derived from the overlying Solon Member of the Cedar Valley Group become increasingly abundant upward in areas where the Davenport Member is extensively brecciated (Sammis, 1978). The Davenport is an evaporite dominated unit in parts of southern Iowa, where nodular, mosaic, and massive gypsum and anhydrite are interbedded with limestone and dolomite (Giraud, 1986). The extensive Davenport breccias are interpreted to have formed by evaporite-solution collapse processes, which were operating, at least in part, during open marine deposition of the lower Cedar Valley Group. The Davenport Member overlies the Spring Grove with apparent conformity, and the contact is gradational or undefinable at some localities. The Davenport Member is about 6 to 10 m thick across most of its extent (3-6 m in northeastern Iowa), but up to 31 m in the evaporite bearing region of southern Iowa.

Figure 5. Brecciated bedrock of the Davenport Member in the Morgan Quarry. Note the variable sizes of the brown limestone clasts in the photo on the left and the angularity of the tan dolomite clasts on the right. (photos by Ryan Clark)

Spring Grove Member. The Spring Grove Member is dominated by thin to medium bedded dolomite, in part calcitic to calcitized. The member is typically laminated and petroliferous; laminations characteristically are laterally continuous. Breccias are commonly present at the base and occur locally throughout the interval in northeastern Iowa. Nodular to mosaic anhydrite is present in the lower Spring Grove in evaporite bearing Wapsipinicon sequences of southern Iowa (Giraud, 1986). The member is generally unfossiliferous, but burrows, stromatolites, and ostracodes have been noted. Ooids are present locally. The Spring Grove ranges from 4 to 7 m in thickness across most of Iowa but is thinner in northeastern Iowa (1-5 m). It overlies the Kenwood Member, apparently conformably, but locally lies on eroded Silurian strata along the Hardin-Bremer High (Bunker *et al*., 1983).

Kenwood Member. The Kenwood Member is dominated by thin bedded, unfossiliferous, argillaceous to shaly dolomite and dolomitic limestone with scattered to abundant quartz/chert silt and sand, locally forming sandstone. It is laminated in part, and locally brecciated to intraclastic. Shale interbeds are noteworthy and nodular, mosaic, and bedded gypsum/anhydrite are present in Kenwood evaporite sequences of southern Iowa (Giraud, 1986). Nodular and irregular masses of mega-quartz are present locally (Fig. 6). The Kenwood ranges from about 4.5 to 8 m in thickness across most of Iowa and northern Illinois; it is generally thinner in north-eastern Iowa (0.5-4.5 m) and reaches a maximum thickness of 13 m in the evaporite bearing region of southeastern Iowa. Where the Kenwood overlies the Spillville and Otis formations, no evidence for an erosional contact at the base of the Kenwood has been identified. However, the Kenwood unconformably overlies Ordovician or Silurian strata throughout most of its extent.

Figure 6. Chert nodule from the Kenwood Member taken from the new pit that exposes the contact between the Devonian and Silurian at the Morgan Quarry. (photo by Ryan Clark)

Silurian – Hopkinton Formation

A new pit excavated into the Morgan Quarry has recently exposed the Silurian for the first time at this location. The Silurian unconformably underlies the Devonian Wapsipinicon Group over much of the region. BMC has been approved to exploit the Hopkinton Formation for aggregate production. The contact between the Devonian and Silurian at the Morgan Quarry is difficult to identify (Fig. 7). The difficulty is caused by a number of factors, such as the fact that the Kenwood Member can appear lithologically similar to the underlying Silurian, the possibility that there is Otis/Spillville (also a fossil moldic dolomite) at this location, and that differential brecciation has obscured the contact (Fig. 8). Further examination is needed to definitively pick this contact. If brecciation is observed to include Silurian bedrock then it would be one of the only instances where such a phenomenon has occurred! The following description of the Hopkinton Formation is adapted from IGS Guidebook No. 11 (Witzke *et al*., 1992).

Figure 7. Sherman Lundy (BMC geologist) and Chad Heinzel (UNI professor) standing at the base of the Silurian pit in the Morgan Quarry. (photo by Ryan Clark)

The Hopkinton Formation consists of four members, in ascending order, the Sweeney, Marcus, Farmers Creek, and Picture Rock. This formation is dominated by gray to buff crystalline dolomite. Although pervasively dolomitized, the formation preserves much of the original limestone fabrics, such as skeletal packstones/grainstones, stylolites, and laminations. The porosity is due to the abundance of crinoid and brachiopod molds. The primary fossil that helps identify the Hopkinton, although it is also found in other Silurian units, is the pentamerid brachiopod (Fig. 9). Veins and vugs filled with tan calcite are also found in the Hopkinton at this location (Fig. 10). The maximum thickness of the Hopkinton Formation is 49 m and rests conformably between the overlying Scotch Grove and underlying Blanding formations.

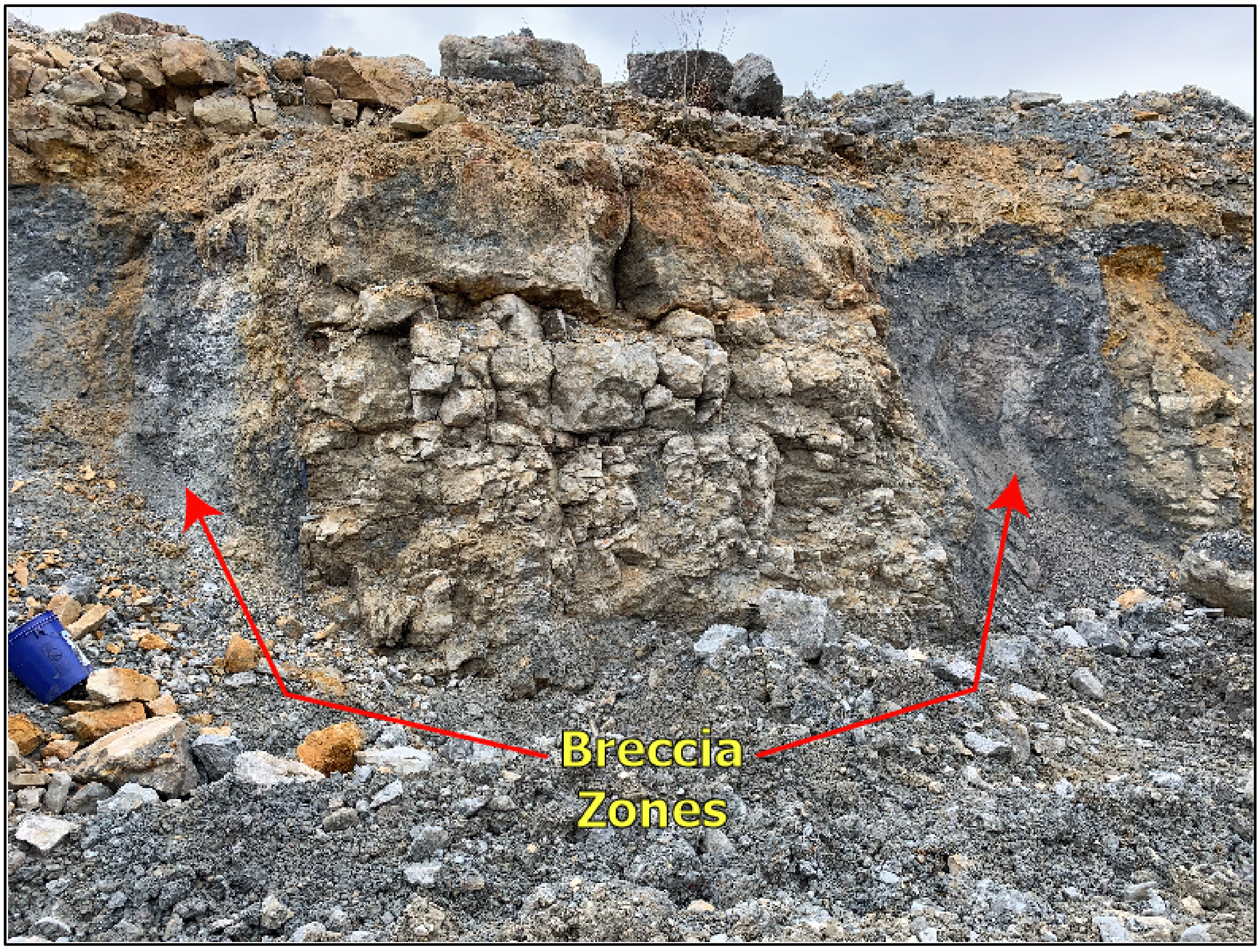

Figure 8. View of the side wall of the Silurian pit showing intact carbonate (Devonian / Silurian?) flanked by zones of extensive brecciation. The breccia appears similar to the Kenwood Member. (photo by Ryan Clark)

Figure 9. Slab of Hopkinton Formation dolomite with pentamerid brachiopod molds. (photo by Ryan Clark)

Figure 10. Vein filled with tan calcite in the Hopkinton Formation seen in the Silurian pit at the Morgan Quarry. (photo by Ryan Clark)

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Stratigraphic Column of the Morgan Quarry