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EARTHSCI 3400: Geology of Iowa

Economic Geology and Natural Resources of Winneshiek County, Iowa

Figure 1: The Galena Limestone near Decorah

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Abstract

Past geologic events often have a significant impact on the availability of natural resources and economy of an area. Much of Iowa's bedrock consists of sedimentary rock deposited in the vast epeiric seas that covered the state in the geologic past. In most of the state, sedimentary rock is overlain by glacial sediment that was deposited during quaternary glaciation events. Both bedrock and sediment are important to the local and global economy. Iowa's abundant limestone has historically been used in the aggregate industry, but in recent years mature sandstones than can be found in Iowa have sparked interest from the fracking industry. The soils that overlie much of the bedrock have enormous value, as Iowa has some of the most productive soils in the world. This paper takes a holistic look at the bedrock and stratigraphy of the entire state of Iowa with an emphasis on how past geologic events have affected the availability of natural resources and economic geology of Winneshiek County, Iowa.

INTRODUCTION

The lithology of the bedrock of Winneshiek County, Iowa makes it one of the most economically important areas in the state. The bedrock of Winneshiek County is composed primarily of limestone and dolostone, like much of the state. Limestone is commonly sought after by the construction industry for a wide variety of uses. Unlike the rest of Iowa, abundant sandstone can be found in Winneshiek County. Mature sandstones such as the Jordan and St. Peter have historically been important as they make good aquifers. However, in recent years the use of these formations in the fracking industry as frac-sand has become more common. The presence and abundance of both limestone and sandstone make Winneshiek County very important economically.

Winneshiek County, Iowa is situated in the Northeast Corner of the state. It is bordered by Minnesota to the north, Allamakee County to the east, Fayette County to the south, and Howard and Chickasaw Counties to the west. Winneshiek County is located in a mostly rural setting. As of 2010, Winneshiek County had a total of 21,056 residents, over 8,000 of which reside in its largest city, Decorah. Many of Winneshiek Counties' cities were founded due to their proximity to the counties two major rivers, the Upper Iowa and Turkey. Decorah, Bluffton and Kendallville all are situated near the Upper Iowa River. The Upper-Iowa River flows west to east through the north central portion of the state. The Turkey River flows northwest to southeast, passing through Spillville and Fort Atkinson in the southwest portion of Winneshiek County. The Yellow River begins in southeast Winneshiek County, but has a much smaller watershed than the Turkey and Upper Iowa Rivers. The Upper Iowa, Turkey, and Yellow River are all tributaries of the Mississippi River.

History of Winneshiek County

Settlement of Winneshiek County Iowa began in 1835 by Reverend David Lowery near the Yellow River in eastern Winneshiek County (Alexander, 1882). Lowery was a minister of the Cumberland Presbyterian Church who was sent to the area to improve the conditions of the Native Americans. Under authorization by the government, Reverend Lowery constructed a three hundred acre farm 5 miles southeast of Fort Atkinson with the intent of teaching the Native Americans agricultural practices (Alexander, 1883).

On May 31, 1840, an army frontier post was built in present day Fort Atkinson to protect the Winnebago Indians from other tribes, primarily the Sioux (Figure 2). The Winnebago were being pushed west from their homeland of Iowa and Wisconsin to Minnesota, and the frontier post acted as a temporary home during this relocation. The frontier post was named "Fort Atkinson" after Henry Atkinson, the commanding officer in charge of the relocation of the Winnebago. Its location was chosen due to the topographical high point and proximity to a major water source, the Turkey River (Alexander, 1883). The frontier post was active from 1840-1849.

Permanent settlement of Winneshiek County began as early as 1847 when pioneers and homesteaders first arrived in the area (Becker, 2013). In 1849, following the removal of the Winnebago from Fort Atkinson, many more settlers arrived in the area. The majority of early settlers of Winneshiek County were of German and Norwegian descent (Bailey, 1913). The largest city and county seat of Winneshiek County, Decorah, named for the prominent Winnebago warrior Waukon Decorah was founded in 1949. The area continued to experience growth, and eventually, Winneshiek County was officially founded in 1951 (Bailey, 1913; Becker, 2013). Winneshiek County was named for chief Winneshiek of the Winnebago tribe. Settlement experienced a major boom in 1869 during construction of the railroad in southern

Winneshiek County, which brought many tradespeople and businesses to the area (Becker, 2013).

Figure 2: The frontier post at Fort Atkinson

BEDROCK OF IOWA

Precambrian (4.6 GA – 541 MA)

The geologic history of present day Iowa began 2.9 billion years ago with the deposition of the Otter Creek Mafic Complex, which is believed to represent a sill (Anderson, 1998). Throughout the Precambrian there were multiple major plate tectonic events that shaped the geology of modern day Iowa. A major mountain building event, the Penokean Orogeny took place 1.8 billion years ago and is partially responsible for Iowa's igneous basement material. Another event, the midcontinent Rift System nearly tore apart central North America 1.1 billion years ago, depositing much of Iowa's basaltic basement material (Van Schmus, Hinze, 1985).

The Sioux Quartzite, found in Lyon County in northwest Iowa (Figure 3) is a 1.6 billion year old Quartzite formation (Anderson, 1998). In some areas, the Sioux Quartzite reaches 7,800 feet in thickness. The upper portion of the Sioux Quartzite was deposited in a tidal/shallow marine environment, whereas the lower portion was likely deposited in a fluvial environment. This could likely be attributed to marine transgression (Anderson, 1998).

Cambrian (541 – 485 MA)

Cambrian age bedrock can be found in Winneshiek and Allamakee counties in northeast Iowa (Figure 3). Iowa's Cambrian is interpreted as a shallow marine transitional environment. There is a major unconformity at the base of the Iowa's Cambrian followed by shale and sandstone deposition. Most of Iowa's Cambrian age bedrock is localized to Allamakee County. However, outcropping of Iowa's youngest Cambrian formation, the Jordan Sandstone can be found in Winneshiek County as well (Figure 6).

Ordovician (485 - 443 MA)

Most of Iowa's Ordovician age bedrock can be found in the northeast corner of the state in Winneshiek, Allamakee, Fayette and Clayton Counties (Figure 3). Iowa's Ordovician is dominated by marine transgression. Sandstones and sandy/muddy carbonates such as the Saint Peter Sandstone dominate Iowa's early Ordovician, suggesting shallow seas with abundant continental/clastic input. Iowa's middle Ordovician is marked by sea level transgression and the deposition of shales such as the Decorah and Glenwood. By the late Ordovician, bedrock becomes increasingly muddy and carbonate rich, indicative of further marine transgression (Anderson, 1998). The end of Iowa's Ordovician is marked by rapid marine regression and a major uniformity (Calvin, 1905).

Silurian (443-419 MA)

Silurian age bedrock can be found in east-central Iowa (Figure 3). Iowa's Silurian is marked by abundant carbonate deposition indicative of a shallow marine depositional environment (Anderson, 1998). Colonial and solitary Coral, Brachiopod, and Crinoid fossils can be found in much of Iowa's Silurian age bedrock. Notable formations include the Hopkinton, which is a dolostone that can be found in both Maquoketa Caves and Backbone State Parks and the Gower, which is a dolostone that was used in many of Iowa's early buildings including Cornell College and Anamosa State Prison.

Devonian (419-358 MA)

Devonian exposures can be found throughout east central Iowa (Figure 3). There are 13 Devonian age formations in the state, most of which are limestone and dolostone. During the flood of 1993, the Devonian Fossil Gorge near Coralville was revealed. The Devonian Fossil Gorge is a horizontal expanse of Devonian age seafloor with abundant Colonial Coral, Brachiopod and Crinoid fossils. Much of Iowa's Devonian age formations are used commonly in the construction industry as road and concrete aggregate.

Lower Carboniferous (Mississippian) (358 – 323 MA)

The Mississippian represents the last epeiric seas in Iowa. Exposures can be found from north-central to southeast Iowa (Figure 3). The Mississippian is known for abundant limestone deposition, and this holds true for Mississippian bedrock in Iowa as well. Oolitic rocks are common, indicative of high energy coastal depositional environments (Anderson, 1998).

Upper Carboniferous (Pennsylvanian) (322 – 298 MA)

Pennsylvanian bedrock can be found in much of central to south-central Iowa (Figure 3). During the Carboniferous, Iowa was situated in transitional environment, cyclically alternating from marine to non-marine depositional environments (Anderson, 1998). The main control of sea-level during this time period was glaciation, which occurs in $10^4 – 10^5$ year intervals, in phase with Milankovitch cyclicity (Miall, 2003). As a result, much of the lithology of much of Iowa's Pennsylvanian age bedrock varies cyclically in response to sea level change from sandstone, to shale, to limestone, with occasional coal seams (Anderson, 1998).

Mesozoic (232 – 66 MA)

There is no Permian or Triassic and bedrock in Iowa. The Fort Dodge formation is the only Jurassic age formation that can be found in Iowa. It consists primarily of Gypsum with occasional clastic material (Anderson, 1998). There is a major unconformity; accounting for 50 million years of between Iowa's Jurassic and Cretaceous. Cretaceous bedrock encompasses nearly the entire northwest corner of the state (Figure 3). Iowa's Cretaceous record begins with the Dakota formation, which consists of poorly sorted sandstones and conglomerates, with occasional siltstones and shales, indicative of estuarine, fluvial and nearshore depositional environments (Anderson, 1998). The late Cretaceous is marked by abundant shale deposition, indicative of marine transgression.

The Manson Impact Structure is a 74 million year old crater formed by an extraterrestrial impact in Calhoun County, Iowa. The impacting object is estimated to have been over one mile in diameter. Following the discovery of the Manson Impact Strucutre, it was linked to the Cretaceous – Paleogene extinction event, but this has since been disproven by radiometric age dating (Anderson, 1998).

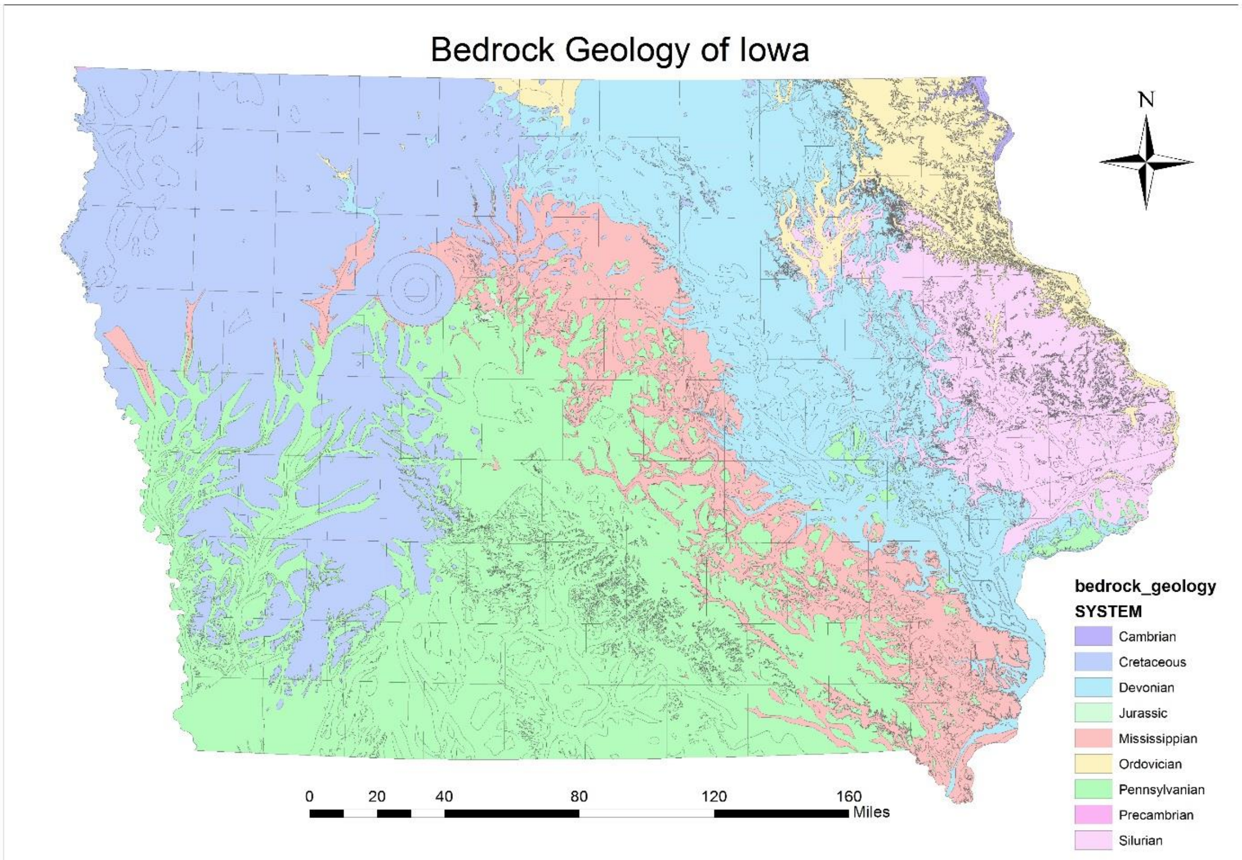

Figure 3: Bedrock Geology of Iowa

Iowa's Landform Regions

Southern Iowa Drift Plain

There are seven major landform regions of Iowa that reflect the surficial process, glacial history and topography of a given area. Iowa's largest landform region, the Southern Iowa Drift Plain is located in south central to southern Iowa and is characterized by extensive fluvial development. There is abundant Wisconsinan age Loess Cover, overlying Pre-Illinoian glacial material. The glacial material has been subjected to well over 500,000 years of erosion. As a result, it has little effect on drainage and surface topography (Anderson, 1998).

Des Moines Lobe

The Des Moines Lobe represents of central to north-central Iowa represents Iowa's last major glaciation. The most recent glacial episode, the Wisconsinan, occurred from 40,000 – 12,000 years ago. This area is characterized by abundant glacial till with minimal loess cover. There are occasional karst areas, but for the most part surface drainage is poor, making this area much less agriculturally productive than the rest of the state (Prior, 1991).

Loess Hills

The Loess Hills of west-southwest Iowa are very unusual compared to much of the state. The area is characterized by areas thick loess cover, reaching over 200 feet in some areas, and sharp terrain (Andrerson, 1998). Since loess erodes easily, relatively steep terrain has been carved by surface runoff and fluvial activity. Most of the Loess in the Loess hills is 12,000 – 25,000 years old, resulting from the Wisconsinan glacial advance (Prior, 1991).

Northwest Iowa Plains

The Northwest Iowa Plains is characterized by an amalgamation of features of Iowa's other landform regions. Landscapes are gently rolling with abundant branching streams and wide stream valleys (Prior, 1991). The eastern portion of the Northwest Iowa Plains contains Wisconsinan age glacial material. Varying thicknesses of Loess Cover can be found throughout the region, with the thickest cover near the western portion (Prior, 1991).

Iowan Surface

The Iowan Surface encompasses north-central to northeast Iowa. Topographical relief is low in this region, and fluvial systems are well developed (Anderson, 1998). Glacial material of Pre-Illinoian age can be found, but is covered by a thin layer of loess in many areas. The Iowan surface contains most of Iowa's karst areas, the majority of which are localized to Floyd County (Anderson, 1998).

Paleozoic Plateau

Iowa’s northeast corner is part of the part of the Paleozoic Plateau landform region. The Paleozoic Plateau is characterized by bedrock controlled surface topography with relatively thin loess and glacial material (Anderson, 1998). The bedrock of this area is almost entirely Cambrian and Ordovician in age. Bedrock topography is steep throughout this region and surface runoff is extensive. This area is home to many of Iowa’s cold-water streams.

Alluvial Plains

The Mississippi and Missouri Alluvial Plains are the flat lowlands near the Missouri and Mississippi Rivers on the western and eastern edge of the state. The Alluvial Plains represent flood plains formed by the Mississippi and Missouri Rivers during periods of high increased flow. The formation of these landform regions has been linked to periods of high melt-water flow following recent glacial episodes (Anderson, 1998).

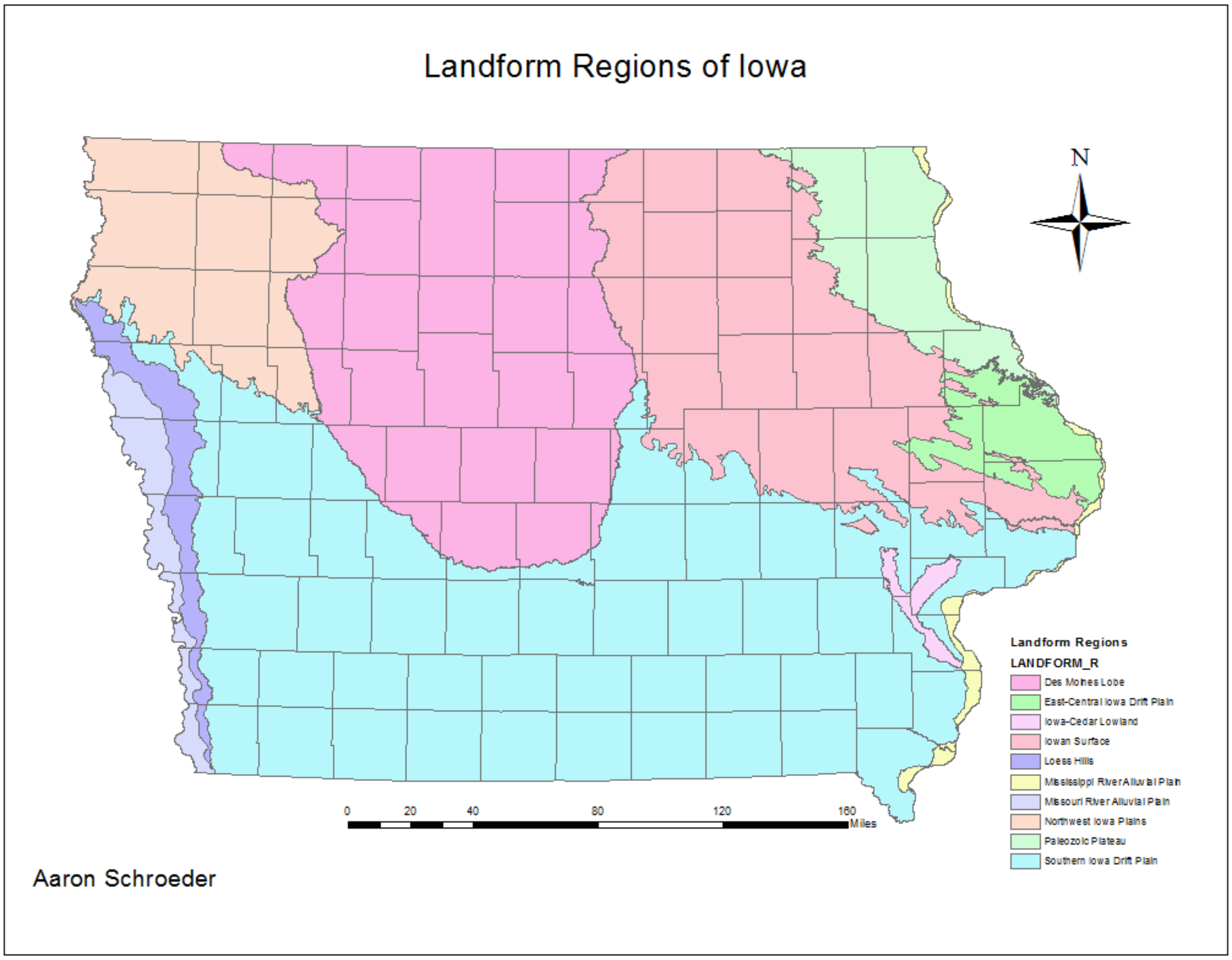

Figure 4: Landform Regions of Iowa

BEDROCK GEOLOGY OF WINNESHIEK COUNTY

Cambrian (541 – 485 MA)

Winneshiek County's stratigraphic record begins in the Cambrian with the Jordan Sandstone. The Jordan Sandstone is a coarse, well-rounded, quartz rich sandstone with minimal clay minerals present (Anderson, 1998). The maturity of the Jordan is indicative of a high energy depositional environment, likely tidal or shallow marine (Calvin, 1905; Byers, Dott, 1994, Anderson, 1998). There are relatively few outcrops of the Jordan in Winneshiek County, all of which can be found in the northeast portion of the county (Figure 6). (Calvin, 1905) Due to its high permeability, the Jordan is commonly used as an aquifer in not only Winneshiek County, but throughout much of the upper Midwestern United States (Byers, Dott, 1994)

Ordovician (485 - 443 MA)

Winneshiek County's Ordovician age bedrock consist many alternating layers of limestone, sandstone and shale, suggestive of multiple marine regression and transgression events. The Oneota Limestone lies at the base of Winneshiek County's Ordovician Rock record. The transition from the marine sandstone of the Jordan to the Oneota Limestone is likely a product of marine transgression (Calvin, 1905). The Oneota Limestone is overlain by the New Richmond Sandstone followed by the Shakopee Limestone. Exposures of these lower Ordovician age bedrock are uncommon in Winneshiek County. The few exposures that do exist can be found along the Upper Iowa River valley in the northern and eastern portions of the county (Calvin, 1905).

A 3.5 mile wide crater known as the Decorah impact structure lies the central portion of Winneshiek County. The Decorah Impact Structure was formed by a meteorite impact during the middle Ordovician (470 MA). A six-foot long sea scorpion known as *Pentecopterus* *decorahensis* was found among the sediment and exceptionally preserved species of brachiopods, conodonts and fish species that filed in the crater. It is largest known Ordovician age predator. The Decorah impact structure is overlain by the 18-27 meter thick Winneshiek shale, which allowed it to remain undiscovered until 2008 (Thompson, 2013).

The Saint Peter Sandstone is the oldest formation with abundant outcropping in Winneshiek County. The Saint peter is super mature sandstone, composed almost completely of quartz, with other materials removed by weathering. It's resistance to weathering makes it a dominant control of topography in much of the northeastern portion of the county. The Saint Peter can only be found in the northeastern portion of the county, and decreases in thickness as it moves to the southwest (Calvin, 1905). The Glenwood Shale overlies the Saint Peter, but is only 5-10 feet in thickness in most areas (GeoSam, 2016).

The Platteville Limestone overlies the Saint Peter Sandstone and Glenwood Shale in Winneshiek County. The Platteville formation ranges from fully dolomitized in some areas to partially and undolomitized in other areas (Brower, 2006). The undolomitized Platteville outcrops along the Upper Iowa River on the north side of Decorah (Calvin, 1905). The Platteville is commonly used as aggregate in road construction and surfacing and is characterized by abundant crinoid fossils (Brower, 2006). The Decorah Shale is a roughly 25 foot thick shale that overlies the Platteville Limestone. The base of the Decorah shale is argillaceous, but it becomes more calcareous and fossiliferous as you move up, with abundant colonial bryozoan fossils, suggesting marine regression (Calvin, 1905). Exposures of the Decorah formation can be found near Winnebago Street with the Decorah City limits.

The Galena Group (Figure 1) is the most prominent limestone in Winneshiek County. It is fairly uniform in thickness at around 225 feet. The Galena is responsible for the abundant cliffs and bluffs that can be found near the Upper Iowa River valley throughout northern Winneshiek County; however, it only appears at the surface in southwest Winneshiek County near Ossian and Castalia (Calvin, 1905). The most notable outcrops can be found near Bluffton, where cliffs reach 100 feet in height along the Upper Iowa River. However, there is not a single location where the entire thickness of the Galena is exposed. The thickness and abundant marine fossils of the Galena suggest it was deposited in a calm marine environment (Anderson, 1998). In contrast to most of the Galena throughout Iowa, the Galena near Decorah has not been dolomitized; likely due to the underlying Decorah Shale impeding the migration of Magnesium into the formation (Calvin, 1905).

The Maquoketa Formation overlies the Galena and is split into four members; the Brainard Shale, Fort Atkinson Limestone, Clermont Shale, and the Elgin Shale/Limestone (Calvin, 1905). The Fort Atkinson Limestone is a cherty dolomite that reaches up to 40 feet in thickness in some areas (Figure 5). Marine fossils, primarily brachiopods can be found in the lower part of the Fort Atkinson Limestone. Outcroppings of the Fort Atkinson Limestone can be seen in southern Winneshiek County near Fort Atkinson. Outcroppings of the other formations in the Galena group are mostly localized to the south in Fayette County (Calvin, 1905).

Figure 5: The Fort Atkinson Member of Maquoketa Formation near Fort Atkinson

Silurian (443-419 MA)

The Waucoma Limestone is the only Silurian age formation that occurs in Winneshiek County. The few outcroppings that do occur can be found in southern Winneshiek County between Festina and Fort Atkinson (Calvin, 1905). The Waucoma is distinguishable in that it is much less fossiliferous than underlying bedrock, suggesting a higher energy depositional environment (Calvin, 1905).

Devonian (419-358 MA)

Devoinian exposures can be seen in much of western Winneshiek County. The Wapsipinicon group lies at the base of Devonian strata. The Spillville formation is the oldest formation of the Wapsipinicon group that can be found in Winneshiek County. The Spillville is a dolostone/limestone which can be distinguished by abundant Stromatoperoid, and Triobite fossils (Calvin, 1905; Anderson, 1998). It is overlain by the Pinicon Ridge formation, which is similar in characteristics to the Spillville. Outcroppings of both the Spillville and Pinicon Ridge formations can be found in western Winneshiek County near Spillville and Ridgeway. The Little Cedar Formation, which is part of the Lower Cedar Valley Group overlies the Pinicon Ridge Formation. Outcroppings can be found in southwest Winneshiek County, from west of Fort Atkinson to the Winneshiek-Chickisaw county line. However, there are very few exposures of Devonian age bedrock at the surface (Calvin, 1905).

Surficial Geology

Winneshiek County is situated on both the Paleozoic Plateau and Iowan Surface landform regions. Much of Winneshiek County lies in the Paleozoic Plateau landform region. However, the southwest corner of the county is part of Iowan Surface. As a result, there is a dramatic change in surficial features throughout Winneshiek County. Surface topography the Iowan Surface portion of Winneshiek County is much less sharp than the rest of the county. Loess cover is much more significant in this region, and outcroppings are much less abundant. Most of Winneshiek County is part of the Paleozoic Plateau landform region. In this area, surface topography is very sharp and rock outcroppings are abundant. Loess and glacial drift are uncommon in the Paleozoic Plateau and bedrock is the principal control of surface topography (Anderson, 1998). The Upper Iowa River and many of its cold-water tributaries can be found in northern Winneshiek County within the Paleozoic Plateau region.

Evidence of Pre-Illinoian (Kansan) age glacial drift can be found in the eastern third of Winneshiek County near Castalia. It has been hypothesized that all of Winneshiek County was covered by glaciers during this time, but erosion and weathering has since removed evidence of the glaciation (Calvin, 1905).

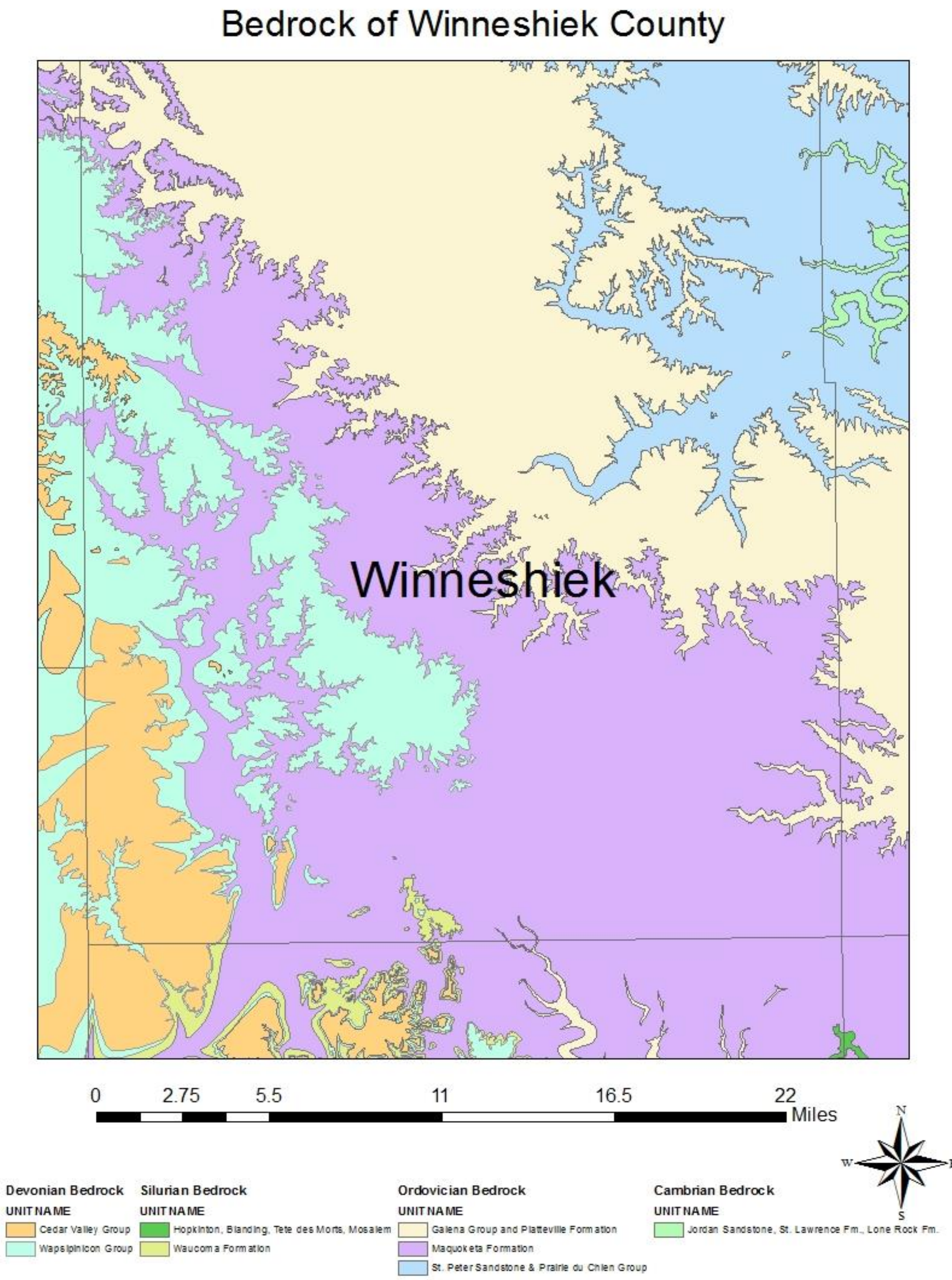

Figure 6: Bedrock Geologic Map of Winneshiek County

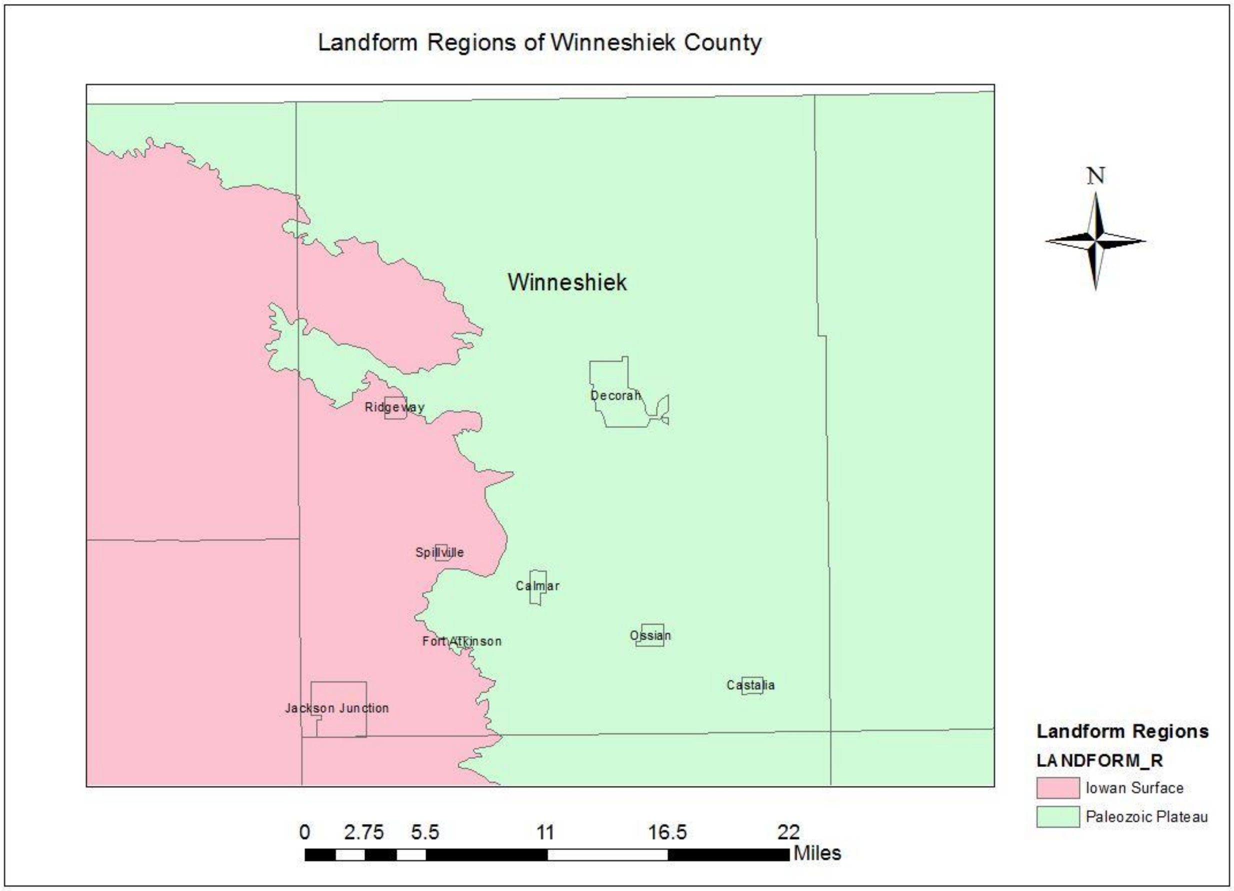

Figure 7: Landform Regions of Winneshiek County

NATURAL RESOURCES OF WINNESHIEK COUNTY

Soils

Like much of Iowa, the primary resource of Winneshiek County is its highly productive soils. Winneshiek County's soils vary from shallow and less productive in the Paleozoic Plateau region of the county to thicker and more productive in the Iowan surface portion of the county (Calvin, 1905). The Paleozoic Plateau region of Winneshiek County is very well drained with abundant small streams and creeks, as a result soils in this area have much less time to develop and are less productive. Soils in the Iowan surface region of Winneshiek County are better developed with abundant calcareous glacial material and organic matter (Calvin, 1905). Corn is the most common crop in Winneshiek County, covering 62% of the county's farmland (Census of Agriculture, 2012). The average corn suitability ration of Winneshiek County is around 58, making it slightly less productive than the state average of 62 (Census of Agriculture, 2012).

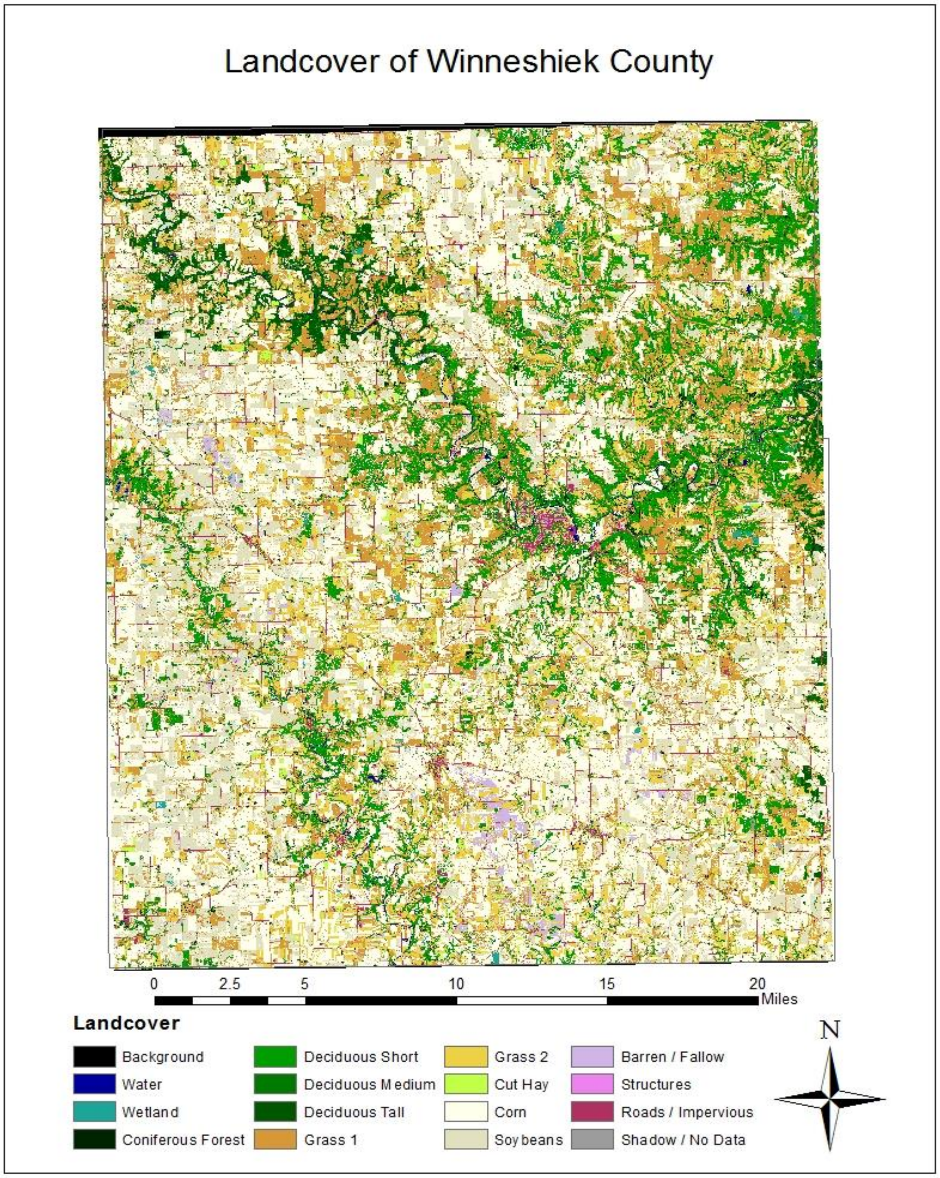

Figure 8: Landcover Map of Winneshiek County

The Fayette Series is the most abundant soil series in Winneshiek County. Its taxonomic class is fine-silty, mixed, superactive, mesic typic hapludalfs. Typic hapludalfs such as the Fayette are formed from loess, and are characteristically deep and well drained with 24-32 % clay content (USDA, 2015). The Fayette Series is common on crests, uplands, and stream terraces and can be found in both the Paleozoic Plateau and Iowan Surface region of Winneshiek County (Figures 9 and 10). However, there are some significant differences in soil types throughout Winneshiek County. The Downs Series is very common throughout the Paleozoic Plateau region (Figure 10). The Downs is very similar to the Fayette Series and is classified as a fine-silty, mixed, superactive, mesic mollic hapludalfs. The Downs has more sand, silt and rock fragments and is slightly less agriculturally productive (USDA,2015). The Whalan Series is common in the Iowan Surface region of Winneshiek County (Figure 9). The Whaelan Series is classified as a fine-loamy, mixed, superactive, mesic typic hapludalfs. It is distinctive in that grain size is smaller than the downs and Fayette, and permeability is lower (USDA, 2015).

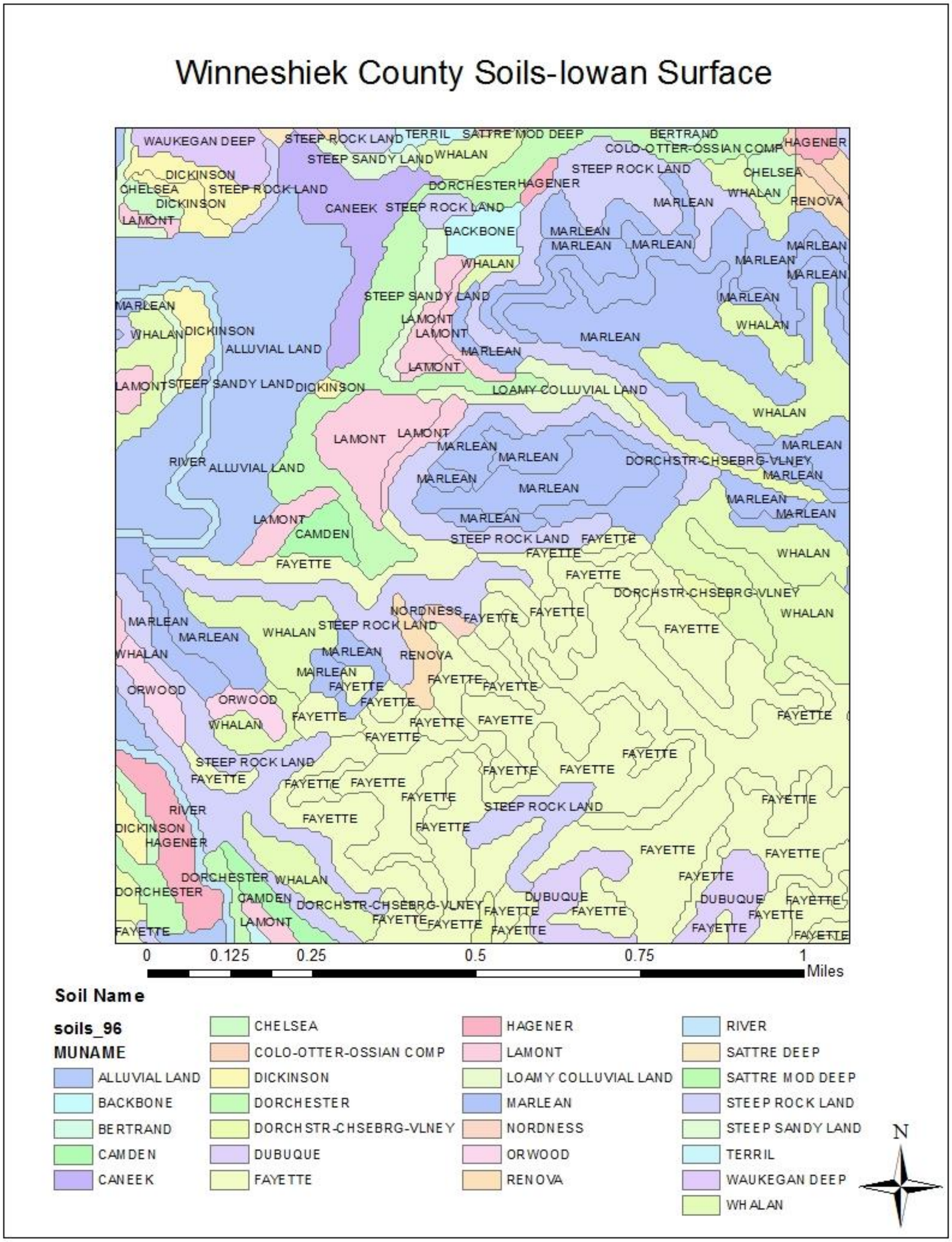

Figure 9: Soil series of the Iowan Surface region of Winneshiek County near Fort Atkinson

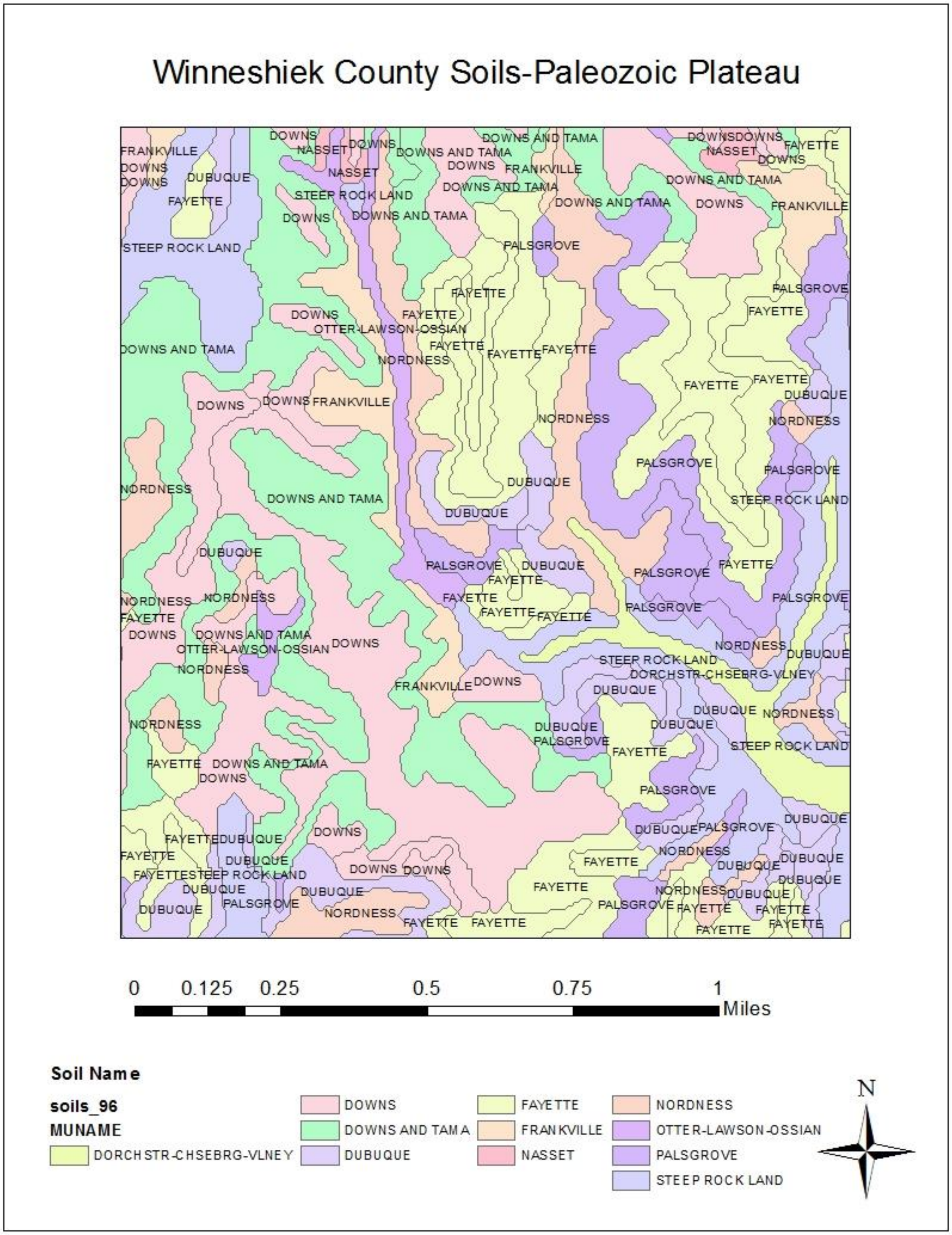

Figure 10: Soil series of the Paleozoic Plateau region of Winneshiek County near Decorah

Bedrock

Winneshiek County’s bedrock has been quarried for use in both building stone and construction aggregate. Winneshiek County is located in a rural setting and has numerous gravel roads, which are the primary use of material mined in Winneshiek County. Many of Winneshiek County’s early buildings were constructed using Ordovician age Oneota Limestone (Calvin, 1905). The Oneota Limestone is highly dolomitized and as a result, is very resistant to weathering. In the past, the Platteville Limestone was heavily quarried for building stone, however, buildings constructed from Platteville Limestone are of a much lower quality than buildings constructed using the Oneota Limestone, as it hasn’t undergone dolomitization and is much less resistant to weathering (Calvin, 1905; Brower, 2007). Many of Winneshiek County’s limestone formations are quarried for aggregate and road materials. The Galena Group and Maquoketa Formation are most commonly mined for aggregate and road material due to their abundance in both eastern Iowa and Winneshiek County (Calvin, 1905). The Fort Atkinson Member of the Maquoketa Formation was used to construct the frontier post in Fort Atkinson in 1840 (Figures 2 and 5).

In recent years, hydraulic fracturing or “fracking” has increased in popularity as a means to obtain natural gas. Hydraulic fracturing uses a pressurized liquid to fracture bedrock. Sand is then injected into these cracks to keep them open, allowing for migration of natural gas. The Jordan and Saint Peter Sandstones of Winneshiek County are both of interest to the fracking industry as their mature, well rounded grains make them ideal for use as frac-sand (Brouse et al., 2015). Fracking is known to have numerous environmental consequences, and has been linked to earthquakes and groundwater and air pollution. Mining of frac-sand can also have environmental consequences, and has been linked to increased particulate matter in air. The formations that would be used for frac-sand, the Jordan and Saint Peter, are important aquifers for much of the county as well. For these reasons, frac-sand mining in Winneshiek County has been met with heavy opposition.

Basement Material

In recent years it was discovered that Winneshiek County's basement material could have enormous economic potential. The Midcontinent Rift System nearly pulled apart central North America 1.1 billion years ago forming the Northeast Iowa Plutonic Complex. There is a possibility that abundant deposits of economically valuable metallic minerals such as copper, nickel, titanium and platinum are contained within this complex (Drenth et al., 2015). The Northeast Iowa Complex was discovered due to magnetic and gravitational anomalies. The magnetic characteristics of northeast Iowa's basement complex are similar to the Duluth Complex near Lake Superior, which also formed as a result of the Midcontinent Rift System and is known to contain abundant metallic mineral deposits. The Duluth Complex is estimated to contain 64 billion dollars-worth of metallic minerals (Blake, 2014), and it is theorized that the Northeast Iowa Complex could have similar economic potential. Reaching the Northeast Iowa Plutonic Complex to determine its economic potential is difficult, as it is buried under roughly 2,000 feet of sedimentary material. The deepest well in Winneshiek County can be found Bruening Rock Products' Skyline Quarry (Figure 11) north of Decorah and reaches 1,600 feet deep (Blake, 2014). It is estimated to that the well would have to go down at least another 250 feet to reach the potential mineral deposits. This project is progressing slowly and it is estimated that mining in Winneshiek County won't occur for at least a decade. Mining in Winneshiek County has been further complicated by the recent discovery and interest in the Decorah impact structure, which lies within the area where metallic mineral deposits may be present.

Figure 11: Skyline Quarry near Decorah

Conclusion

Much of Iowa can be characterized by fertile soils and carbonate deposition, with high potential for the agriculture and aggregate industries. Winneshiek County's geological setting makes it one of the most economically important areas in Iowa. The soil, bedrock and basement material all have high economic potential. However, the rich history and geologic history, notably, the recent discovery of the Decorah Impact Structure makes accessing these resources difficult. In the future it will be interesting to see if the economic potential of the basement material outweighs the paleontological importance of the Decorah impact structure.

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