The Geology, Hydrogeology, and Related Industry of Southwestern Wisconsin and Northeastern Iowa

Field Trip Guide Book

October 5th and 6th, 2007

Conducted By

WGWA

The Wisconsin Ground Water Association
An affiliate of the National Ground Water Association

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Introduction

By President-Elect Lee Trotta

"The geologic history and correlation of Upper Cambrian and Lower and Middle Ordovician rocks in the Upper Mississippi Valley area have long been the subject of study and controversy" (Meredith Ostrom, 1970). While the controversy has died down since "Buzz" Ostrom spoke those words, the areas of southwest Wisconsin and northeast Iowa visited in this trip are still the best places to study these rocks. That's because we are in the "Driftless Area" where there are little or no glacial deposits to mask the bedrock. That doesn't mean that there aren't alluvial deposits throughout the region. Truly it is the rivers that tell the story here and we have just the experts along on this trip to interpret that story.

The Grant River, Boice Creek, Bloody Run, Turkey River, Little Platte River, Little Green River – the streams we cross read like a litany from a trout lover's Bible. We are in the cradle of some of the best trout fishing in the U.S. We are lucky to have scheduled our trip after the fishing season has ended or we would never get participants back on the bus between stops. And then there is the mighty Mississippi River! There is too much to see and too little time to see it. We will get brief overviews of some of the area's more important stratigraphy, geomorphology, groundwater flow features, groundwater threats, and history. For detailed discussions the reader is referred to the citations in this guidebook.

Geographic orientation for the field trip is provided by the highway route maps (Figures 1 and 2). Geologic orientation is provided by the geologic map (Figure 3) and the stratigraphic cross section (Figure 4).

The Committee gratefully acknowledges the comments and suggestions of Paul Van Dorpe, Treasurer of the Iowa Ground Water Association. We also wish to thank the sponsors of this field trip which include Legette Brashears & Graham, Inc., Probe Technologies, Inc., RSV Engineering, Inc. and Bill Van De Yacht Water Well Drilling, Inc.

Our stop leaders have also put hard work into this guide and their years of research enhance each stop. They are:

Matt Tschirgi (Iowa Dept. of Natural Resources)
Ray Anderson (Iowa Dept. of Natural Resources)
Mike Bounk (Iowa Dept. of Natural Resources)
Gary Siegwarth (Iowa Dept. of Natural Resources)
Troy Thompson (Summit Envirosolutions)
Bruce Brown (Wisconsin Geological & Natural History Survey)
Ron Abby (Majestic View Dairy Farm)

James Knox (University of Wisconsin –Madison)

Thanks to each and every one who has helped put together this great field trip!

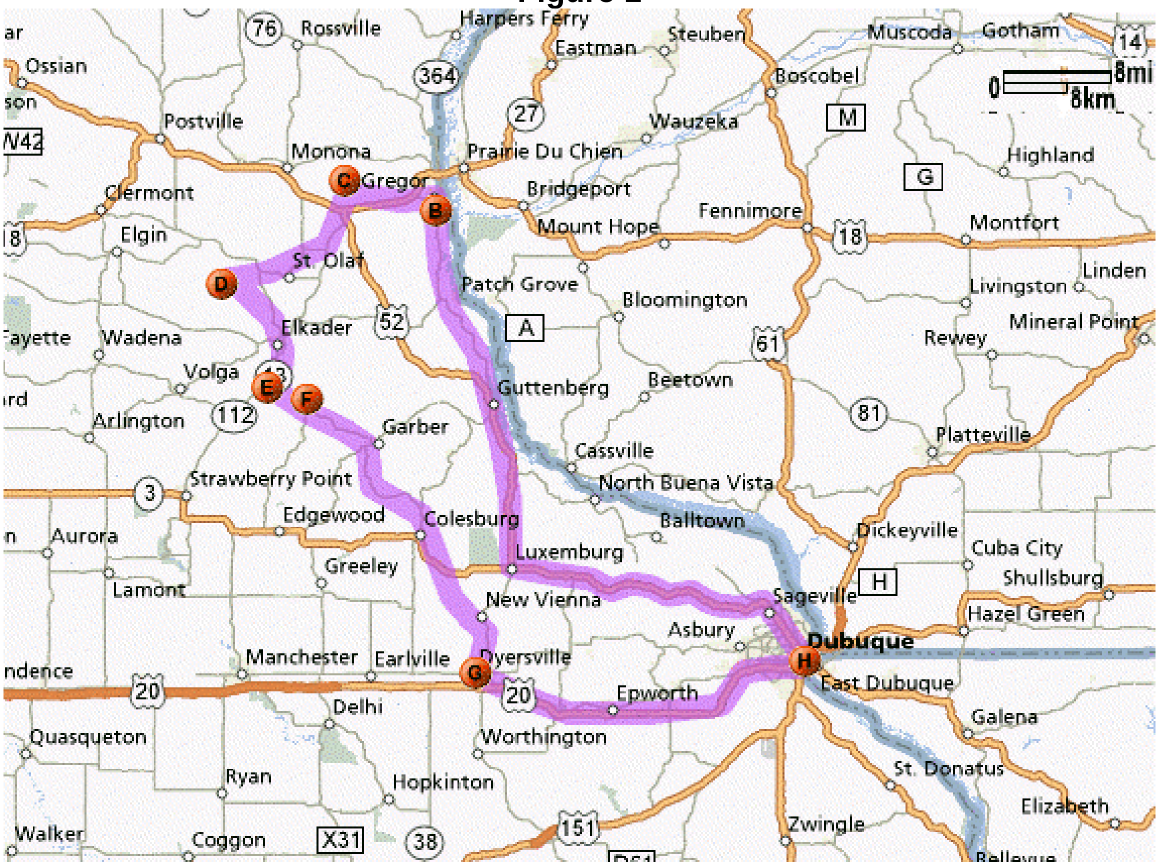
Field Trip Committee
Lee Trotta (WGWA-President-Elect)
Paula Richardson (WGWA-Guidebook Compiler)
Troy Gawronski (WGWA)
Jim Drought (WGWA)
Jason Lowery (WGWA)
Ken Wade (WGWA)
Jeff Stoner (MGWA)

~Lee Trotta

Overview

Friday October 5, 2007 Itinerary

Figure 1



A. Grand River Ctr, 500 Bell St, Dubuque, IA 52001, 563-690-4500

B. Pikes Peak State Park, 15316 Great River Rd, Mc Gregor, IA 52157, 563-873-2341

C. Spook Cave & Campground, 13299 Spook Cave Rd, Mc Gregor, IA 52157, 563-873-2144

D. Big Springs Trout Hatchery, 16212 Big Spring Rd, Elkader, IA 52043, 563-245-2446

E. Chicken Ridge, Elkader, IA 52043

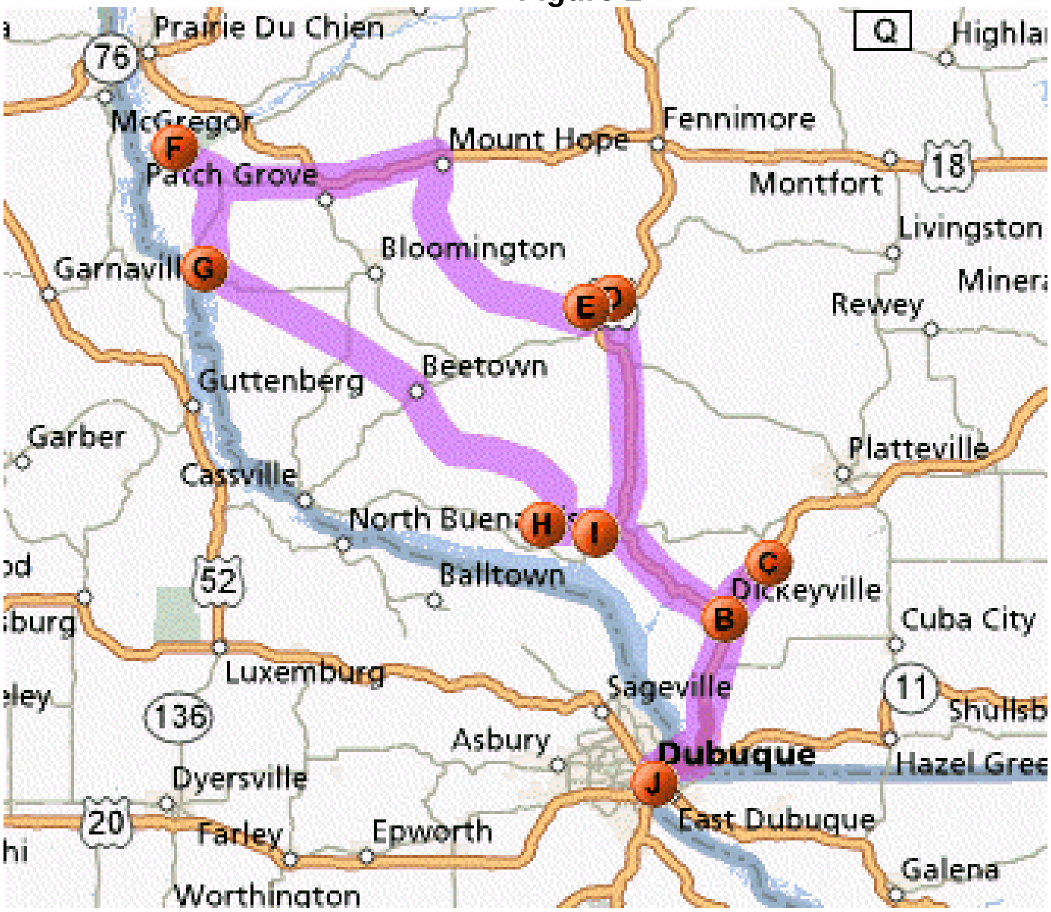
F. Wilhelm Weitling's Utopia, Communia, IA

G. Ethanol plant, Dyersville, IA

H. Grand River Ctr, 500 Bell St, Dubuque, IA 52001, 563-690-4500

Saturday October 6, 2007 Itinerary

Figure 2



A. Grand River Center, 500 Bell St, Dubuque, IA 52001 563-690-4500

B. Hwy 151 Roadcut, Dickeyville, WI

C. Hoadley Hill Roadcut, Hwy 151 & Airport Rd, Platteville, WI 53818

D. Majestic View Dairy Parlor, 5532 Commercial Rd, Lancaster, WI 53813 608-723-2457

E. **Schreiner Park,** 999 Schreiner Park Rd, Lancaster, WI 53813

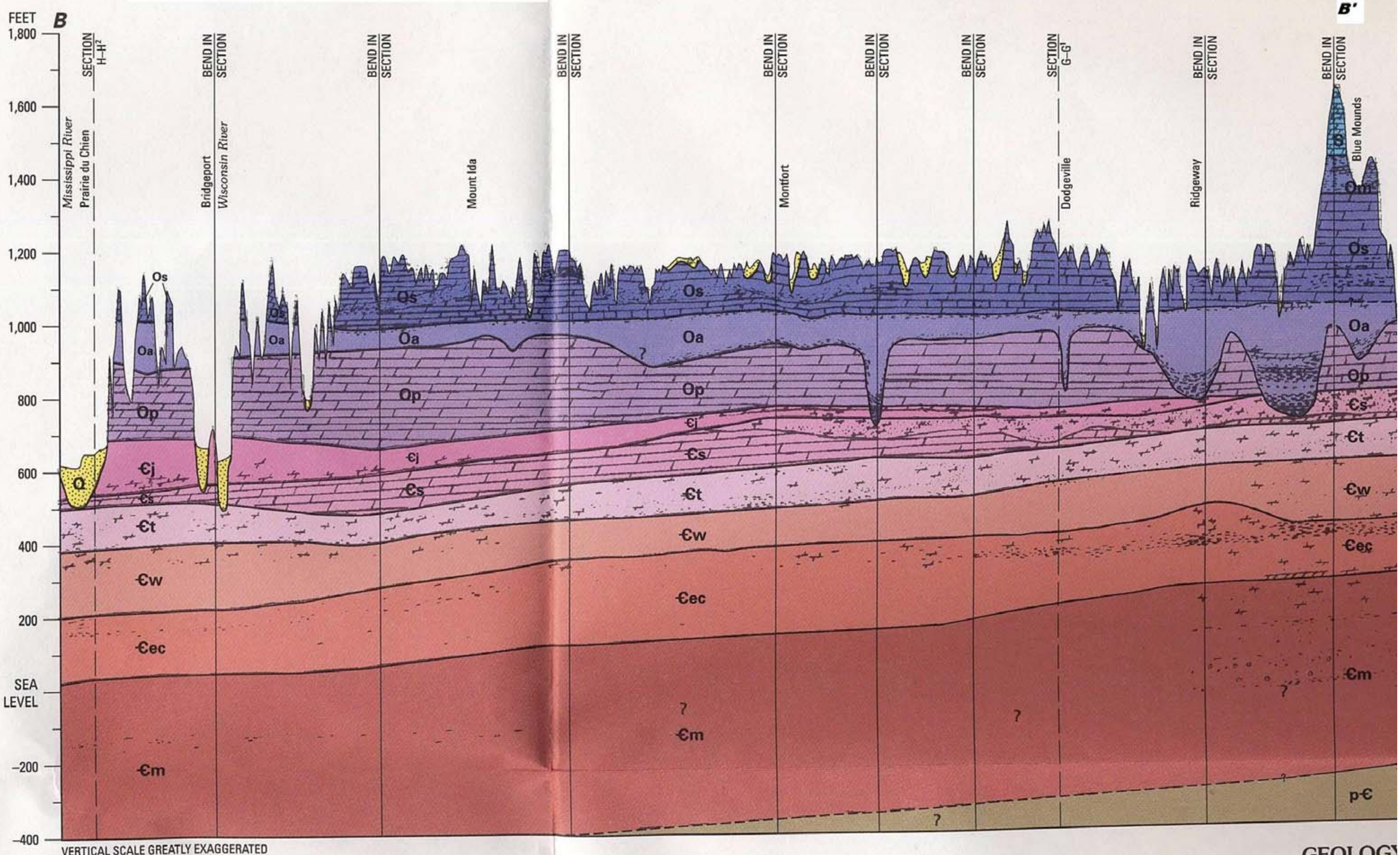
F. Wyalusing State Park, Bagley, WI 53801 608-996-2261

G. Don Orr Gravel Pit, Bagley, WI

H. Boice Creek Alluvium, Potosi, WI

I. St John Mine, 129 S Main St, Potosi, WI 53820 608-763-2121

PRAIRIE DU CHIEN TO BLUE MOUNDS



GEOLOGY

plotted by Lee Trotta
from USGS HA-731 (1998)

WYALUSING/FENNIMORE SECTION EXPLANATION by Lee Trotta

What Does the Geologic Section B-B' from Prairie du Chien to Blue Mounds Tell Us?

The horizontal distance between the City of Prairie du Chien and the Village of Blue Mounds is about 74 miles.

The geologic abbreviations used are Q = Quaternary, S= Silurian, Om = Maquoketa, Os = Sinnipee, Oa = Ancell, Op = Prairie du Chien, Cj = Jordan, Cs = St. Lawrence, Ct = Tunnel City, Cw = Wonewoc, Cec = Eau Claire, Cm = Mt. Simon, and pC = Precambrian.

Bedrock layers are fairly flat along that stretch, except for the contact between the Ancell Group (St. Peter sandstone) and the Prairie du Chien dolomite.

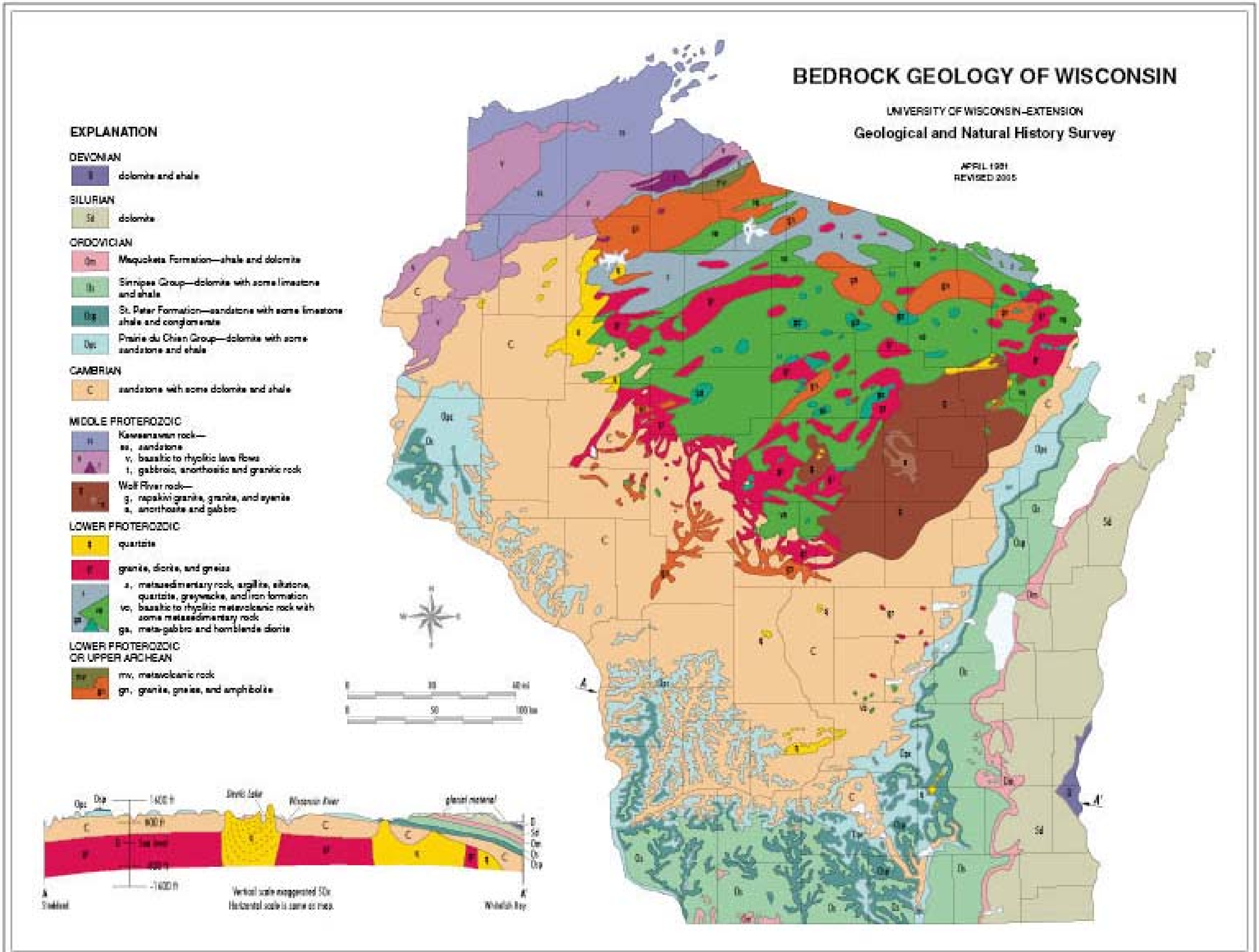
About 100 ft of the Ancell Group is exposed at Wyalusing State Park (the cliff represented east of Bridgeport). The Ancell Group ranges from less than 40 feet thick near Fennimore (bend in section east of Mt Ida) to over 300 feet thick east of Montfort and near Blue Mounds.

The underlying Prairie du Chien dolomite is about 200 feet thick at Wyalusing, but is eroded away completely in the major river valleys and areas where the Ancell Group is over 250 feet thick.

Note the bedrock valley for both the Mississippi and the Wisconsin Rivers are approximately the same depth. Both rivers likely get groundwater inflow from the Jordan sandstone and seeps in the overlying dolomite. The river areas are in turn recharge areas for the “deep sandstone” aquifer. Quaternary deposits are present in these valleys and they fill areas below the ridgetops between Fennimore and Dodgeville.

Areas of highest relief are capped by a more-resistant dolomite bedrock type. An area near Ridgeway, where the dolomite cap is eroded away, probably acts as a recharge area to the “deep sandstone” aquifer. The land surface at Fennimore (bend in section east of Mount Ida) is about at the level of the Decorah shale, the middle component of the Galena-Decorah-Platteville formations grouped together as the Sinnipee Group. This shale often contains brachiopod and bryozoan fossils.

The Precambrian surface is at least 400 feet below Sea Level near Wyalusing and the overlying Mount Simon sandstone is at least 600 feet thick. These depths were verified by deep exploration holes drilled by the USGS for this project at nearby Bagley and Red Mound.


BEDROCK GEOLOGY OF WISCONSIN
UNIVERSITY OF WISCONSIN–EXTENSION
Geological and Natural History Survey
APRIL 1981
REVISED 2005
EXPLANATION
DEVONIAN
dolomite and shale
SILURIAN
dolomite
ORDOVICIAN
Maquoketa Formation—shale and dolomite
Sinnipee Group—dolomite with some limestone and shale
St. Peter Formation—sandstone with some limestone shale and conglomerate
Prairie du Chien Group—dolomite with some sandstone and shale
CAMBRIAN
C
sandstone with some dolomite and shale
MIDDLE PROTEROZOIC
Keweenawan rock—
ss, sandstone
v, basaltic to rhyolitic lava flows
i, gabbroic, anorthositic and granitic rock
Wolf River rock—
g, rapakivi granite, granite, and syenite
a, anorthosite and gabbro
LOWER PROTEROZOIC
quartzite
granite, diorite, and gneiss
s, metasedimentary rock, argillite, siltstone, quartzite, greywacke, and iron formation
vo, basaltic to rhyolitic metavolcanic rock with some metasedimentary rock
ga, meta-gabbro and hornblende diorite
LOWER PROTEROZOIC
OR UPPER ARCHEAN
mv, metavolcanic rock
gn, granite, gneiss, and amphibolite
Ops
Os
Opc
Sd
Om
Osp
glacial material
Wisconsin River
Vertical scale exaggerated 50x.
Horizontal scale is same as map.
A
A'

Pikes Peak State Park

15316 Great River Road
McGregor, IA

Raymond R. Anderson
Iowa Geological Survey
Iowa City, Iowa 52242-1319
Raymond.Anderson@dnr.iowa.gov

The northeast Iowa area around Pikes Peak State Park is one of the most beautiful and interesting regions of Iowa. The region is rich in history, with the precipitous rock bluffs recording a geologic history beginning nearly 530 million years ago and continuing today as erosion along the Mississippi River (Fig. 1) and its tributaries expose ever-more of the rock record. Many plant and animal communities have inhabited the region, changing and evolving with climatic and cultural changes. The long history of Native American residents is symbolized by the large number of mounds on ridge tops and in the valleys on high terraces, many shaped as animal effigies. The arrival of Father Marquette and Louis Joliet in the region in 1673 opened a new phase of rich and interesting history. Hunters, trappers, and miners were the earliest historic residents. The region became a part of the United States with the purchase of the Louisiana territory in 1803, and was explored by Zebulon Pike shortly thereafter. Military forts were constructed, towns established, and roads constructed. Pikes Peak State Park was the subject of a Geological Society of Iowa (GSI) field trip in the fall of 2000, and the length of the guidebook (Anderson, 2000) prepared for that trip is a testimony to the natural bounty and colorful history of this region. That guidebook includes articles discussing the National Fish & Wildlife Refuge, Effigy Mounds National Monument, the Corps of Engineers construction of the Mississippi River lock and dam system, and Wisconsin's Wyalusing State Park across the river. It also includes discussions of such special area residents as Andrew Clemens and the Ringling Brothers. A hard copy of the GSI guidebook is available for sale from the Iowa Geological Survey, and it may be obtained as a downloadable pdf file at http://www.igsb.uiowa.edu/gsipubs/pdf/GB70.pdf. You can also enjoy a virtual field trip of Pikes Peak Park at http://www.igsb.uiowa.edu/gsi/gb70/page_1.htm, on the

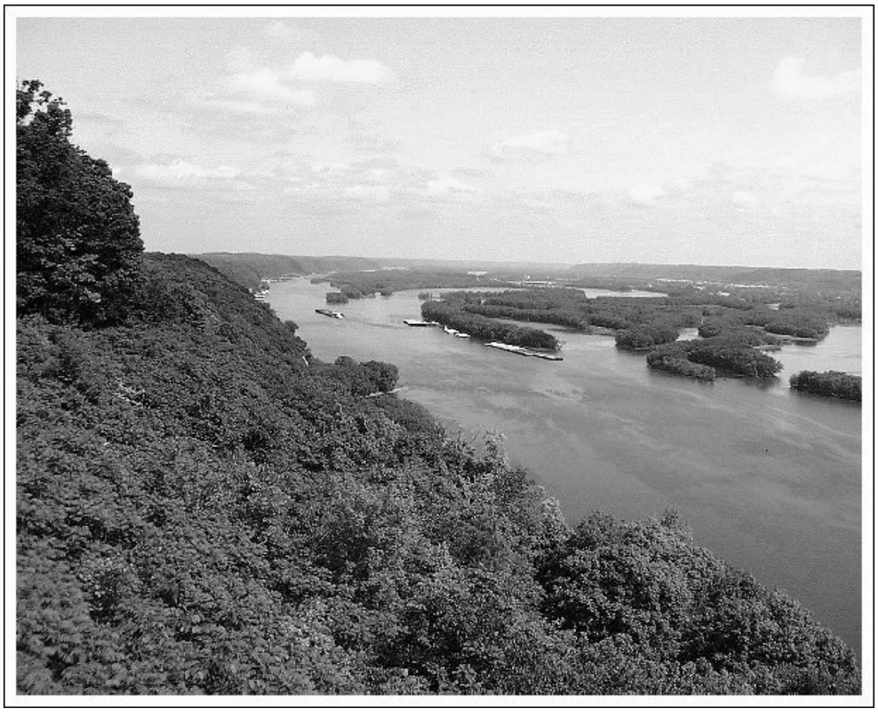


Figure 1. The Mississippi River looking north from Pikes Peak.

Geological Society of Iowa web site. The abbreviated guide to Pikes Peak State Park that was prepared for the Wisconsin Ground Water Association Fall 2007 field trip includes excerpts of that GSI guidebook, with a some additional information.

Pikes Peak Park Manager Matt Tschirgi and I hope that you find the material in this guidebook and the field trip experience to be informative and interesting.

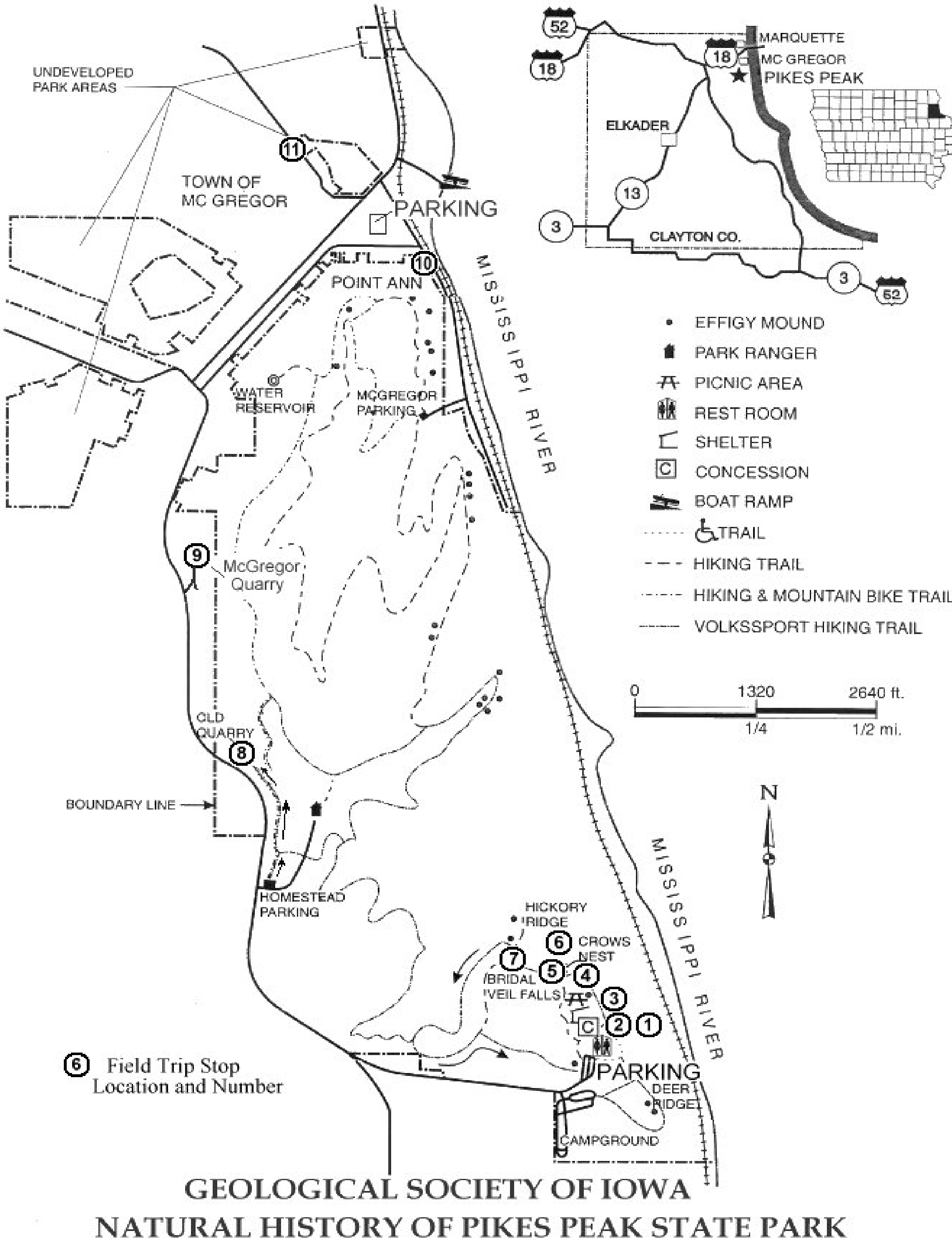


Figure 2. Map of Pikes Peak State Park showing field trip stops from Geological Society of Iowa Guidebook 70, "The Natural History of Pikes Peak State Park, Clayton County, Iowa" (Anderson, 2000).

History of Pikes Peak State Park

modified from Farnsworth (2000)

Pikes Peak State Park lies on the eastern edge of a unique part of the state referred to as the Paleozoic Plateau by naturalists. "The Peak" as it is locally known is located just south of McGregor on a bluff about 500 feet above "The River" (as the Mississippi is known locally) (Fig. 3). The park offers modern camping, picnicking and a place from which you can view and explore an area rich in history and prehistory.

Figure 3. A two-tiered overlook was recently constructed at Pikes Peak, providing a full access view of the scenic river valleys.

Origins of Pikes Peak State Park

Among the earliest residents of this region were Native Americans of the Woodland Culture (800 to 1200 A.D.) These peoples sculpted earthen "effigy" mounds on ridge tops, in the shapes of animals, to celebrate their oneness with Mother Earth. Many of these mounds remain today as a monument to these people and a reminder to us that we are also of the earth.

In 1673, the first white men to see what is now Iowa, explorers Louis Joliet and Father James Marquette, reached the mouth of the Wisconsin River and beheld the great, unknown river now known as the Mississippi. Following the Louisiana Purchase, the government sent Zebulon Pike in 1805 to explore the Mississippi Valley and identify locations suitable for military posts. Pike recognized this area as an important, strategic point, and an excellent location for a fort. Government officials agreed on the vicinity but chose the prairie around Prairie du Chien (now Wisconsin) to construct the fort. Several years later, Pike was again sent westward by the government where he scouted and named Pikes Peak in Colorado.

In 1837, Alexander McGregor began a ferry service to cross the Mississippi River. McGregor's Landing was established on the west ferry landing, and the town that grew at that site now bears his name.

The core of Pikes Peak State Park is a 960 acre plot that was part of a parcel of land once owned by Martha Buell Munn, granddaughter of James MacGregor, Alexander's MacGregor brother. The Pikes Peak portion of these parcels was always a favorite family picnic spot, and the MacGregors' and Munns' protected it from being logged for firewood to feed the hungry riverboat boilers. Several old oaks in the picnic area, estimated to be over 300 years old, bear testament to this protection. A relative of Martha Munn, James B. Munn of New York, offered the land as a gift to the Upper Mississippi River Wildlife and Fish Refuge in 1928. The original gift consisted of Pikes Peak, Point Ann, McGregor Heights, and a few smaller parcels of land.

The lands were originally donated to the federal government, with deed restrictions stating that the land must be used for a park. Although sentiment was strong for the creation of a National Park along the Mississippi River, the Great Depression struck before the park could become reality. When the New Deal social programs of the Thirties were instituted to combat unemployment, Iowa was ready. Visionary Iowa naturalists including McBride, Pammel and Shimek, working with the Iowa Conservation Commission, had already designed a state park system, with several parks already established and others in advanced states of planning. Because development of Iowa's state park system was well underway, the federal government, by act of Congress, deeded the Munn property to the State of Iowa.

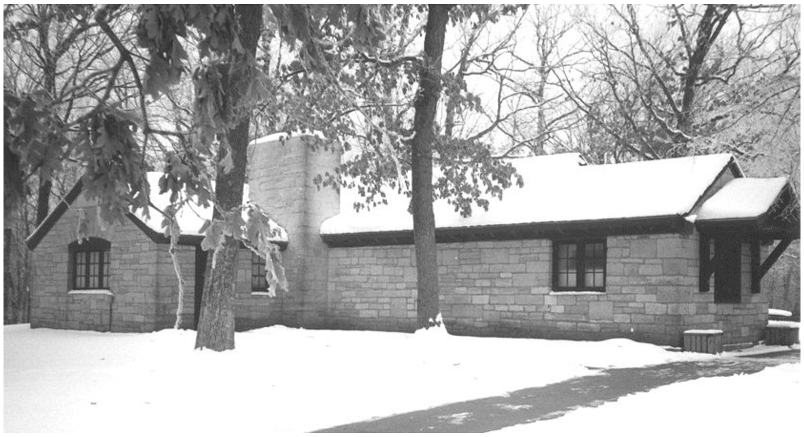


Figure 4. Pikes Peak's concession stand was constructed by the CCC in the 1930s.

Originally the state considered three separate parks for land, Pikes Peak, Point Ann just south of McGregor, and McGregor Heights o n the bluffs north of town. In the mid thirties work at the Pikes Peak portion was commenced by a Civilian Conservation Corps (C.C.C.) company (Fig. 4). Point Ann, McGregor Heights, and the other parcels were not initially developed. Then, in the late 1960's and early 1970's, the Iowa Conservation Commission started acquiring the private lands between Pikes Peak and Point Ann to expand the park to the north. The park now consists of 960 acres with 13 miles of trails winding through it.

More recently Pikes Peak has undergone a major renovation. Two overlook structures were constructed, providing access to the magnificent views of the Mississippi and Wisconsin rivers to all. Concrete walks were constructed to connect many of the parks attractions to the parking area, and a series of boardwalks and improved trails give firm footing and easy access to many other areas, such as Bridal Veil Falls and the Bear Mound adjacent to the picnic area. The overlooks and boardwalks are kept clear of snow in the winter. The picnic area has a playground for the kids, modern toilets and a park store for snacks and souvenirs. The 77 unit camp area has modern shower and rest rooms facilities (open May through October), non-electric, 30 and 50 amp electric sites and 23 camping pads requiring very little leveling.

Archaeology of Pikes Peak State Park

modified from Green (2000)

People have lived in northeast Iowa for at least 13,000 years. Pikes Peak State Park contains a wealth of archaeological resources relating mostly to one segment of this time span, the Late Woodland period, ca. A.D. 600-1100. Sixty-five Woodland mounds have been documented in 11 separate groups within the main portion of the park. Several probable habitation sites also have been found. The large number of archaeological sites in the park indicates that Pikes Peak, like the adjacent Mississippi and Wisconsin River valleys, was heavily utilized in prehistoric times, particularly during the Woodland period.

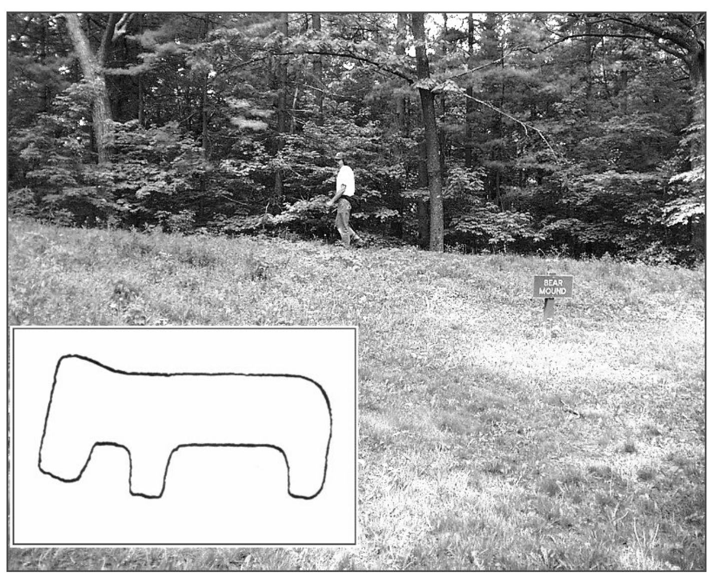


Figure 5. Photograph of the Bear Mound near the concession stand at Pikes Peak State Park. The insert is a sketch of the mound made by Ellison Orr in 1939.

The Pikes Peak mound groups, situated on bluff tops and narrow upland ridges, contain four bear effigies (Fig.5), eight linears, and 53 conical mounds. Most of the mounds at Pikes Peak and nearby locations probably were built by people of the Effigy Mound "culture" of the Late Woodland period. Mound construction appears to have been a ritual and ceremonial practice. The mounds covered and honored the dead and also symbolized the connections between humans, spirits, and the landscape. The effigies may represent animate spirits, while the linear and conical mound shapes have uncertain meanings.

Late Woodland people located their campsites, villages, and other habitation and special-purpose sites throughout the landscape. They made repeated use of rock shelters and nearby terraces and floodplain surfaces. Mississippi River islands served as warm-season camp locations for exploitation of fish, shellfish, and other resources, while rock shelters served as cool-season habitations.

Pikes Peak and its surroundings have been subjected to periodic archaeological study over a period of 125 years or longer. The most extensive surveys were those of self-taught local archaeologist Ellison Orr in 1912 and Luther College archaeologist R. Clark Mallam in 1973 and 1978. Not every part of the park has been intensively inspected, so it is likely that additional sites will be found if more of the park is carefully surveyed. Enough has been discovered to permit a useful review of ancient cultures and their uses of the local landscape. Additional information is available in (Mallam et al. 1979) and in Sellars and Ambrosino (1989).

The Mississippi bluffs in northeast Iowa contain one of the highest concentrations of mounds in North America. Effigy Mounds National Monument, Pikes Peak State Park, and other public lands preserve and interpret this unique heritage. Despite damage from looting and plowing that occurred before Pikes Peak was dedicated as a state park, the archaeological studies at the park have shown that many of the sites are still well preserved and worthy of continued protection. Pikes Peak thus plays an important role in preserving ancient mounds and making them available for public view.

Note: Burial mounds in Iowa are protected by state law. Please report any damage to the DNR and the State Archaeologist.

Quaternary Geology of Pikes Peak State Park

modified from Tassier-Surine (2000)

Pikes Peak State Park is situated along the Mississippi River in Clayton County. The physiographic region surrounding Pikes Peak State Park is markedly different from other landform regions of Iowa. Most notable are the steep-sided cliffs, bluffs, deeply entrenched stream valleys, and karst features. In contrast to other parts of the state where glacial cover dominates, the surficial character of this area is bedrock controlled. The scarcity of glacial deposits led to the original term "***Driftless Area"***, indicating that the area had never been glaciated. However, later studies disproved this idea and the term ***Paleozoic Platea***u was applied (Prior, 1976). Many researchers still use the term "*Driftless Area"* in their descriptions due to the limited exposures of glacial materials in this region.

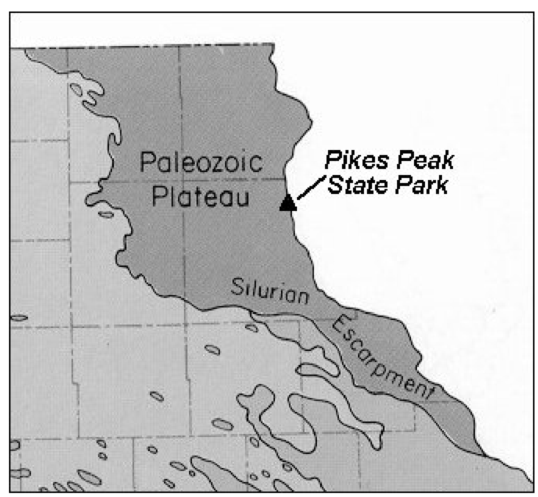


Figure 6. The area now known as the Paleozoic Plateau was formerly called the "*driftless area*".

The Paleozoic Plateau (Fig. 6) region has distinct physiographic features that separate it from any of the other landform regions in Iowa. The southern and western margins boundaries of this landform region are defined along by change from a rugged, dissected, rock-controlled landscape to that of the gently rolling, lower relief landscapes of the Iowan Erosion Surface to the west and the Southern Iowa Drift Plain to the south.

The Paleozoic Plateau region is characterized by an abundance of bedrock exposures with widespread areas of karst topography, deep and narrow valleys, and limited glacial deposits. The steep slopes, bluffs, abundant rock outcrops, waterfalls and rapids, sinkholes, springs, and entrenched stream valleys form a unique physiographic setting. These characteristics combine to form an area of many diverse microclimates that support varied flora and fauna communities not represented elsewhere in the state.

The Mississippi River was a key factor in the development of the Paleozoic Plateau. The river and its tributary valleys contain well preserved terraces, older floodplain deposit remnants, and entrenched and hanging meanders. All of these features indicate the complexity of the alluvial history and river development associated with glacial melting and drainage diversions.

Glacial Till and Loess Deposits

The Paleozoic Plateau region was glaciated multiple times during the Pre-Illinoian. Willman and Frye (1969) identified two tills in Iowa as well as glacial outwash on upland surfaces in the Driftless Area of Illinois. Knox (1982) also showed that Pre-Illinoian till is present in the Wisconsin portion of the area east of the Mississippi River and holds that although there are driftless areas in parts of Wisconsin, that Iowa does not have driftless areas. Additionally, large parts of the Driftless Area in Minnesota show evidence of glaciation as well. Based on work by Hallberg (1980a) it has been determined that two Pre-Illinoian till units, the Wolf Creek and the Alburnett Formations, occur in the Paleozoic Plateau of Iowa.

The younger Wolf Creek Formation cannot be directly dated in northeast Iowa, but based on other studies it is younger than 600 ka, and it is estimated to be about 500 ka indicating the last time glacial ice advanced into this area (Hallberg and Boellstorff, 1978; Lineback, 1979; Hallberg, 1980b). Stream erosion and hillslope development since the last glaciation has resulted in the removal of most of the glacial materials, except those high on the divides, and has produced the dissected landscape we see today (Hallberg et al., 1984).

Upland surfaces are mantled with 3 to 6 meters of Wisconsin age loess which have been radiocarbon dated at 25.3 ± 0.65 ka (Hallberg et al., 1978). The end of loess deposition in Iowa is considered to be about 14 ka (Ruhe, 1969) and this coverage may obscure other glacial deposits. On the primary stream divides, 4 to 6 meters of loess overlies well-drained paleosols developed on Pre-Illinoian tills. The paleosols are generally 1 to 2 meters thick, but locally may be up to 2 to 5 meters thick. These thicknesses and other features are typical of Late-Sangamon paleosols. Yarmouth-Sangamon paleosols are only locally preserved on the divides. The Late-Sangamon paleosol and surface may truncate the Pre-Illinoian till and descend onto the Paleozoic bedrock. (Hallberg et al., 1984)

Mississippi River

Although many early studies suggested that the landform features of the Paleozoic Plateau are very old, more recent research indicates that the modern drainage system and dissected landscape of this region occurred during the Pleistocene. The oldest valley remnants are buried by Pre-Illinoian tills and may be middle to early Pleistocene in age, although the time of incision is not well constrained. Evidence is derived from studies of the upland stratigraphy and erosion, karst systems, fluvial and terrace deposits of the stream valleys, and the dating of speleothems.

Knox and Attig (1988) studied the Bridgeport terrace in the lower Wisconsin River valley, Wisconsin. Paleomagnetic dating of the Bridgeport terrace sediments indicate that they are older than 730 ka. The valley would have had to already be entrenched by this time, indicating a minimum age for these deposits. Therefore, they believe that the Mississippi River between northeast Iowa and southwestern Wisconsin was deeply entrenched by Pre-Illinoian time.

Research summarized in Hallberg et al. (1984) suggests that the Mississippi River and its tributaries are of middle Pleistocene age (500 ka). The major drainage lines were established by Late Sangamon time, however major stream incision probably began prior to the Illinoian. Work by Anderson (1988) concluded that the modern upper Mississippi River Valley likely originated as an ice-marginal stream during the Pre-Illinoian. His model suggested that the Mississippi migrated westward from its original location in central Wisconsin, moving down the proximal face of the crustal forebulge created by a Pre-Illinoian ice sheet that was several kilometers thick.

Wisconsin time represented one of the main periods of valley entrenchment when bedrock-cored, cutoff meanders formed. During the formation of these deep valleys, periglacial activity formed colluvial slopes and karst features collapsed, creating a mantle of bedrock-derived rubble on the steep slopes of related valleys. Between 9 and 25 ka the stream valleys underwent a complex history of erosion and aggradation in response to changes in glacial drainage in the Mississippi River basin. The role of isostatic rebound on the process of stream incision in the area is not clearly understood.

During the past 25 ka in the upper Mississippi River valley, there have been four major episodes of alluvial activity (Knox, 1996). The period between 25 ka and 14 ka was characterized by large quantities of bedload sediment being transported by a braided stream system. This aggradation has been related to outburst floods from glacial lakes and normal meltwater discharge from the Wisconsin glacier. An island braided channel system developed between 14 ka and 9 ka as large discharges from outlet failures of proglacial lakes and sustained low sediment flows caused major downcutting. Modern Holocene climate and vegetation systems developed from 9 ka to approximately 150 to 200 years B.P. The upper Mississippi River returned to aggradation as Late Wisconsin age sediment in tributaries remobilized. Dominant processes during this period involved minor downcutting, channel migration, and the development of fluvial fans and deltas at the junction of tributaries. The fourth episode encompasses the time since European settlement when agricultural land use, channelization, and dam building have greatly impacted the upper Mississippi River.

Bedrock Geology of Pikes peak state park

modified from Witzke (2000)

An instructive and picturesque succession of geologic strata is wonderfully displayed within Pikes Peak State Park. The down-cutting of the Mississippi River Valley has exposed rock strata in bold cliffs and steep ravines, and a number of geologic formations are represented (Fig. 8). The dramatic bluffs in the park tower 300 to 500 feet above the river, and the bluff-tops provide panoramic views up and down the Mississippi River Valley and the Wisconsin River to the east. The highest elevations in the park occur near the park's south entrance and campground (approximately 1130 feet above sea level), and the lowest elevations are along the banks of the Mississippi River (normal river level 611 feet above sea level).

Cambrian Strata

The succession of exposed bedrock strata in the park begins below Point Ann, the bluff adjoining the city of McGregor in the northern area of the state park. The Jordan Sandstone of Cambrian age can be seen in this area (and northward along the highway to Marquette). These sandstones were deposited in shallow and nearshore environments of a vast inland sea that covered the region during the Late Cambrian. The Jordan Sandstone is the youngest Cambrian formation in the Upper Mississippi Valley area, deposited about 505 million years ago. The Jordan Sandstone seen in Pikes Peak State Park represents the farthest south that Cambrian strata are

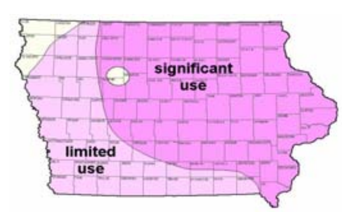


Figure 7. Distribution an use of the Jordan aquifer in Iowa.

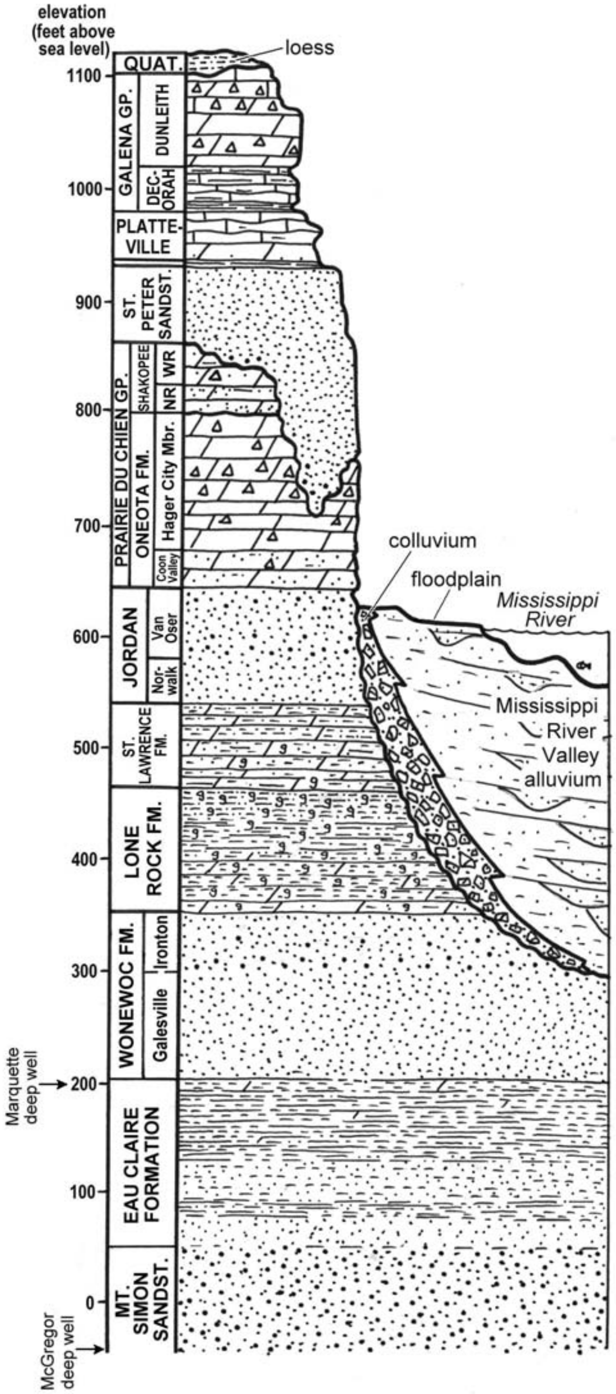


Figure 7. The Geologic section in the area of Pikes Peak State Park.

exposed in the entire Mississippi Valley. Progressively older Cambrian strata can be seen proceeding northward up the Mississippi Valley from McGregor. The same succession of older Cambrian formations occurs beneath the level of the Mississippi River in the park, but these occur in the subsurface buried beneath the Jordan Sandstone. These strata have been encountered in the deep water well in Pikes Peak State Park as well as municipal water wells at McGregor and Marquette. The bedrock channel of the Mississippi River adjacent to Pikes Peak, which is now largely filled with alluvial sediments, is incised 300 feet or more into these Cambrian units, cutting across and into strata of the Jordan, St. Lawrence, Lone Rock, and Wonewoc formations (see Fig.8). The Jordan Sandstone along with the overlying Ordovician Prairie du Chien Group and St. Peter Sandstone comprise the Jordan aquifer. The Jordan aquifer is one of the most important sources of groundwater in Iowa (Fig 7). A properly constructed Jordan well can yield several hundred to over 1,000 gpm, so the aquifer is frequently utilized by municipalities and other high capacity users. Typical Jordan well depth in Iowa range from 300 to 2,000 feet, but some exceed 3,000 feet.

Lower Ordovician Prairie du Chien Group

Lower Ordovician dolomite strata of the Prairie du Chien Group overlie the Jordan Sandstone in the park. Although the Jordan-Prairie du Chien contact does not display significant erosional relief, an episode of missing time is marked at that position in the stratigraphic succession (a disconformity). The Prairie du Chien Group is characterized by ledges of dolomite strata, some containing chert nodules, with minor sandstones and shales also observed. The Prairie du Chien dolomites were formed by chemical replacement of original lime sediments which accumulated in shallow tropical seas that covered much of the interior of North America between about 490 and 505 million years ago. This chemical replacement of original lime sediments composed of calcium carbonate by calcium-magnesium carbonate (the mineral called dolomite) was a later-stage process. Because dolomites differ chemically from limestones, they have sometimes been termed "magnesian limestone" in the older geologic literature.

The Prairie du Chien Group has been divided into two formations, the Oneota below and the Shakopee above. The dominantly dolomitic strata of the Oneota Formation are exposed in the lower bluff faces and lower ravine drainages of Pikes Peak State Park, and in old quarries adjoining the railroad tracks south of McGregor. The Oneota Formation is subdivided into two members, the Coon Valley and the Hager City. The Shakopee Formation, which differs from subjacent Oneota strata in containing some sandstone, shale, and sandy dolomite. The lower Shakopee interval contains sandstone and sandy dolomite (the New Richmond Member), and the upper interval is less sandy and variably cherty (Willow River Member). The Shakopee Formation is not well represented within Pikes Peak State Park, primarily because it has been erosionally removed from much of the immediate area during a prolonged period of erosion that followed the withdrawal of the Prairie du Chien seas from the area.

Middle Ordovician St. Peter Sandstone

The withdrawal of the shallow tropical Prairie du Chien sea initiated an erosional episode that spanned a remarkably long period of time, including portions of the Early Ordovician and much of the Middle Ordovician (approximately 25 million years duration). This period of erosion was characterized by deep weathering across the exposed surface of Prairie du Chien dolomite strata, resulting in the development of an irregular and incised topography. At that time this area occupied a geographic position in tropical latitudes (within about 10º of the equator). Tropical weathering produced a network of caves and sinkholes created by karstic solution of the Prairie du Chien carbonate rocks, and these solutional openings are known to penetrate up to 350 feet though the succession of Prairie du Chien strata in areas of eastern Iowa. Deep valleys were also eroded into this landscape, which in places in the Upper Mississippi Valley area cut through the entire Prairie du Chien succession and into underlying Cambrian strata. In the Pikes Peak area a deep valley was incised through the entire Shakopee Formation and into strata of the Oneota Formation.

The erosional landscape of valleys and sinkholes developed on Prairie du Chien strata was subsequently infilled by a complex sequence of fluvial, estuarine and marine. This infilling was apparently initiated as shallow seas encroached once again into the continental interior of North America. Initially, rivers within the valley systems began to aggrade their sediment load as stream gradients changed in response to rising sea level. As the sea continued to expand into the region, the valleys likely became estuaries along the encroaching coastline. Ultimately the valleys, like the one developed across Prairie du Chien strata in Pikes Peak State Park, entirely filled up with sediment, primarily quartz sand. Iowa Geological Survey geologists recently discovered a lagerstäätte (a deposit containing abundant and/or extraordinarily preserved fossils, some of which preserve animal soft bodies or tissue impressions) in one of these valley infillings near Decorah, about 45 miles northwest of Pikes Peak (Huaibao and others, 2006). The fossil assemblage found in this unit, called the Winneshiek fauna, is dominated by conodonts which are preserved as either individual elements or partial to complete apparatuses but also includes eurypterids, jawless fish, a diversity of arthropods, linguloid brachiopods, mollusks, three-dimensional vermiform fossils, and many indeterminate forms and problematic fossils including several soft-bodied forms.

Once the valleys and karstic openings became filled, the seaway continued to expand over the region depositing a widespread body of sand across the shallow shelf. This valley-filling and shallow-marine sandstone body is known today as the St. Peter Sandstone. The St. Peter Sandstone comprises the thickest formation exposed today in Pikes Peak State Park. It varies from 40 to 55 feet in thickness where exposed in this region, but ranging from 90 and 223 feet in the subsurface to the southwest.

The St. Peter Sandstone is a remarkably monotonous and homogeneous succession of quartz sand (the rock is termed a "quartzarenite"). It appears within Pikes Peak State in thick massive beds, best seen in bluff slopes and steep-walled ravines (as along the Sand Cave trail). The St. Peter is overwhelmingly dominated by very fine to medium grains of quartz sand, with little other material present. The quartz grains are commonly well rounded, and the sedimentologically-mature aspect of the St. Peter quartzarenites suggests that much of the sand was derived by the reworking of older sandstones (like those seen in Prairie du Chien and Cambrian strata). At Pikes Peak, the lower portion of the St. Peter Sandstone where it pilled paleovalleys (as in the Sand Cave area) displays dramatic swirls and bands of red-colored iron-oxide cements (which geologists sometimes term "Leisegang bands").

A relatively thin green-gray shale unit known as the Glenwood Shale caps the St. Peter Sandstone in this region. This shale is only about 4 to 5 feet thick in the park, and because of its soft and easily erodable character, it is typically not well exposed in the wooded ravines. The Glenwood Shale is interpreted to have been deposited as the seaway continued to deepen (transgress) across the region.

Upper Ordovician Platteville Formation

The Platteville Formation is exposed in the upper bluff slopes within Pikes Peak State Park, where it comprises a succession of carbonate rock strata (limestone and dolomite) about 45 feet thick. These strata form the lip of Bridal Veil Falls in the park. The lower part of the formation is characterized by ledges of fossiliferous dolomite (the Pecatonica Member), and upper Platteville strata (the McGregor Member), which form an interval of mostly wavy-bedded limestones, many containing a beautiful assemblage of well-preserved fossils.

The Platteville Formation represents the lithified sediments that were deposited within a broad tropical sea, which supported a diversity of shelled bottom-dwelling animals. The influx of quartz sand, which marked earlier St. Peter deposition, waned and ceased altogether as deposition of the Pecatonica Member proceeded and as shorelines advanced deep into the continental interior. The close of Pecatonica deposition was marked by widespread development of a so-called "hardground" surface, a surface formed across the seafloor at a time when sediment accumulation ceased altogether.

The overlying succession of wavy-bedded to nodular limestone strata comprises the McGregor Member. Fossils are wonderfully preserved in these limestone strata, including brachiopods, crinoids, trilobites, ostracodes, bryozoans, solitary corals, snails, and others. Large nautiloid cephalopods plied the waters in search of prey or scavenge, and very large molds of their chambered shells are found in the Platteville Formation of the area.

Upper Ordovician Galena Group Decorah Formation

The Decorah Formation is a succession of shale and limestone occurring high in bluff slope drainages of Pikes Peak State Park (for example, above Bridal Veil Falls). The Decorah Formation comprises the lower shaley interval of the Galena Group. The Decorah differs from overlying strata of the Galena Group in containing an appreciable content of clay shale. These shales are typically greenish-gray in color and contain fossiliferous lenses and thin beds (commonly brachiopod shell hashes or coquinas) of limestone. Because shales are soft and easily weathered, the shaley portions of the Decorah Formation are typically not well exposed in Pikes Peak State Park. The Decorah Formation in the park includes a lower shale member (the Spechts Ferry Shale), a middle limestone unit (the Guttenberg Member), and an upper shaley interval (the Ion Member). The Spechts Ferry Shale contains two widespread volcanic ashes (known as bentonites) visible as soft pale-colored (whitish to yellow-orange) layers 1 to 2 inches thick within the darker green-gray shale interval. Called "K-bentonites" ("K" for potassium alteration, sometimes lithified by potassium feldspar) by geologists, these bentonites represent volcanic ash falls blown over the interior seaway from distant volcanoes (the volcanic arc lay eastward from present-day Virginia). The ash settled to the sea bottom where it remained largely undisturbed by bottom currents or burrowing organisms. Some of these ash falls were among the largest known in earth history (giant Plinian volcanic eruptions), with individual bentonite beds recognized across vast areas of eastern and central North America and northern Europe. These bentonite beds constitute remarkable time markers, having been deposited in a geologic "instant" over a very large area. The lowest bentonite at Pikes Peak, known as the Deicke K-bentonite in North America (dated at 454 million years old), immediately overlies the Platteville surface. A second bentonite, present about 1 ½ feet higher, is called the Millbrig K-bentonite (dated at 453.7 million years old).

Limestones of the Guttenberg Member overlie the Spechts Ferry Shale. This limestone interval resembles the McGregor Member of the Platteville Formation in possessing wavy to nodular bedded fossiliferous limestone strata. The upper strata of the Decorah Formation at Pikes Peak are included within the Ion Member, which displays interbedded green-gray shales and fossiliferous limestones, and it is notably more shaley than the underlying Guttenberg Member. The Ion is interpreted to have been deposited in shallower environments than the underlying Guttenberg, as evidenced by the progradation of shale from shoreward areas and the higher proportion of abraded and broken shell material.

Upper Ordovician Galina Group Dunleith Formation

The highest Paleozoic bedrock strata found in Pikes Peak State Park belong to the Dunleith Formation, which along with the underlying Decorah Formation comprises the lower half of the Galena Group. These strata form the highest cliffs and ledges above elevations of 1000 feet in the park, and these resistant dolomite and limestone beds are well displayed below the main overlook structure (Fig. 3). In contrast with underlying Decorah strata, the Dunleith Formation contains almost no shale and the carbonate beds are dominated by recrystallized dolomite and dolomitic limestone (unlike the fossiliferous limestones of the Decorah). In addition, the Dunleith contains a considerable quantity of nodular chert ("flint"), whereas underlying Decorah and Platteville carbonates completely lack chert. The Dunleith Formation reaches thicknesses to 80 feet in the park (generally less than 50 feet is represented in the bluff faces). However, the upper part of the formation has been erosionally removed from the park, and the full thickness of the Dunleith in the area is actually about 110 feet. The Dunleith Formation is found in cliffs and bluff faces along the Mississippi River Valley extending southward from Pikes Peak to the Dubuque area.

The Dunleith carbonate strata at Pikes Peak have been recrystallized during dolomitization, and original sedimentary features and fossils are thereby more difficult to distinguish than in the beautiful fossiliferous limestones of the underlying Platteville and Decorah formations. The secondary development of vugs and pores (open spaces and holes) in the dolomite strata has further obscured the fossils and fabrics. Nevertheless, brachiopods, crinoid material, snails, and solitary corals are seen in the park, indicating that the bottom environments in the seaway provided suitable habitat for a diversity of organisms. Relatively large but enigmatic fossils known as receptaculitids (belonging to the genus *Fisherites*) occur within these strata in the park, and the stratigraphic units which contain these fossils are correlatable across a broad region (three receptaculitid "zones" are recognized in the Galena Group). Receptacultids are sometimes called "sunflower corals" because the radiating geometric pattern formed by its skeleton resembles the seed-heads of sunflowers. However, the biologic relationships of receptaculitids are not known with certainty. Various proposals have allied them with corals, sponges, or algae. Receptaculitids share many features in common with calcareous-plated green algae, but certain differences indicate that receptaculitids are a unique extinct group of organisms (possibly allied with green algae).

Northeastern Iowa was subjected to many long-lived episodes of deep erosion marked by the erosional incision and truncation of various bedrock units. Recurring erosional episodes separated periods of shallow marine deposition in the region during much of the Paleozoic Era, but a dominantly erosional landscape was developed across the region later in the Paleozoic (beginning about 300 million years ago). Except for some minor Cretaceous-aged sediments in the area (e.g. at Waukon, Allamakee County), there is no evidence of any deposition in northeast Iowa for a period of time spanning most of that 300 million year interval. Pikes Peak was certainly subjected to the erosional downcutting of bedrock strata seen across the region during that prolonged period of erosion. Nevertheless, the steep erosion of bluff slopes and ravine drainages which has produced the dramatic and picturesque landscape of Pikes Peak State Park is primarily a reflection of erosional processes relating to the more geologically-recent incision of the Mississippi River Valley and its tributaries during the Quaternary Period, which includes the Pleistocene ("Ice Age") and Holocene (Recent) epochs.

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Spook Cave

13299 Spook Cave Road
McGregor, IA
Michael Bounk
Iowa Geological Survey

Spook cave is developed in the cherty limestone of the Dunleith Fm. of the Galena Group, and the underlying Ion Member of the Decorah Fm. which in this area is mainly limestone with shale partings.

The cave was discovered in the 1950s by Gerald Mielke, who, drawn by sounds in the bluff believed locally to be the sound of “spooks,” dug open the spring entrance, thus discovering the cave. He then excavated the floor of the downstream most-part of the cave, with equipment lowered through a now sealed entrance, and finally excavated to the cave from the surface. A dam was built downstream of the cave, flooding the first several hundred feet of passage so that it would be accessible by tour boats. The cave tour is by boat.

Solutional cave development commonly begins when the limestone or dolomite bedrock is completely saturated with groundwater. This water is contained primarily in fractures and bedding planes in the rock. There is normally little or no intergranular porosity, such as in sandstone. This water is slightly acidic, due to the presence of carbon dioxide from the air. Groundwater moves through the horizontal bedding planes slowly dissolving rock in all directions thus producing an elliptical shaped horizontal passage. The passage will often follow the major near vertical fracture trends. As erosion lowers the land surface, the water table and zone of saturation are also lowered, causing the passage to become partly air filled, with a stream on the floor. From this time onward, the stream mainly erodes downward, just like a surface stream. This will eventually produce a keyhole shaped passage, with the stream flowing in a canyon below the original elliptic passage.

Spook Cave is at the phase where the passage is partly air filled, but canyon formation has not yet occurred. Therefore, when the dam is opened and the pond drained, you see a relatively low wide passage. Water flowing downward through near vertical fractures has produced the vertical shafts or domes that you see overhead. Water flowing down the walls of these domes and from fractures in the ceiling has deposited the calcium carbonate speleothems which you see. Because the water flow is through open fractures in carbonate aquifers, such as this one, there is no filtering of pathogens such as you have in sandstone.

Beyond the end of the tour, the passage continues for about 250 Ft. to where it sumps, or goes completely underwater,

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Big Springs Trout Hatchery

16212 Big Spring Road
Elkader, IA

Gary Siegwarth

Big Spring Trout Hatchery is one of three state owned trout rearing facilities in Iowa. Approximately 150,000 rainbow and brook trout are reared to catchable size at the hatchery and stocked in streams throughout norteast Iowa.

Water supply for the hatchery is fed by the largest coldwater spring in Iowa. Flows from the spring usually range from 20,000 to 30,000 gallons per minute, but can exceed 150,000. The Big Spring Basin is a showcase for large sinkholes and losing streams. The stop at Big Spring will include a brief stop at a very large sinkhole within the watershed of the spring.

The Big Spring Watershed is one of the most well known and studied watersheds in the nation when it comes to information on groundwater in a karst dominated landscape. The spring also serves as a highly visible and measurable water quality barometer for land use and other agricultural practices within the watershed. Spring water quality is a direct reflection of surface water inputs from the agriculture dominated landscape.

Chicken Ridge

Highway 13 and Chicken Ridge Road
Elkader, IA
Driveby

Chicken Ridge is the Iowa version of the Niagara Escarpment. To the southwest lie the Silurian and younger-aged bedrock formations which form the famous Iowa flatlands. On this drive-by stop, we will drive the picturesque road between the Turkey River valley and the ridge.

Wilhelm Weitling's Utopia

Communia, IA
Driveby
Lee Trotta

The communitarian settlement Communia was established in northeastern Iowa in 1847 by a group of German immigrants of social utopia convictions. After a few years of economic and social difficulties, they asked for help from the Arbeiterbund (a working man's league recently established in the United States). In 1851 they formed relations with Wilhelm Weitling, the leader of this worker's union. Using union funds, they grew and prospered for a short time. Weitling moved to Communia to try to keep order, but the commune gradually degenerated and was dissolved in 1859. If you walk the fields south of our bus route, you can still see the outlines of former communal homes and pathways.

Ethanol Plant

Dyersville, IA
Driveby
Troy Thompson

The Dyersville ethanol plant, being built by U.S. BioEnergy, is representative of the explosion in ethanol plant construction across the Midwest. Ground breaking for the 100 million gallon per year plant was in March. The Dyersville location, like all such ethanol plants, is based on a combination of factors including available corn supply, access to sufficient natural gas, access to major highways and rail lines (ethanol cannot be shipped by pipeline), and sufficient land area for the plan. Other factors include financial and regulatory ones such as financing, permitting, and tax incentives. Many states, including Wisconsin, are still playing catch-up with establishing adequate review and approval processes.

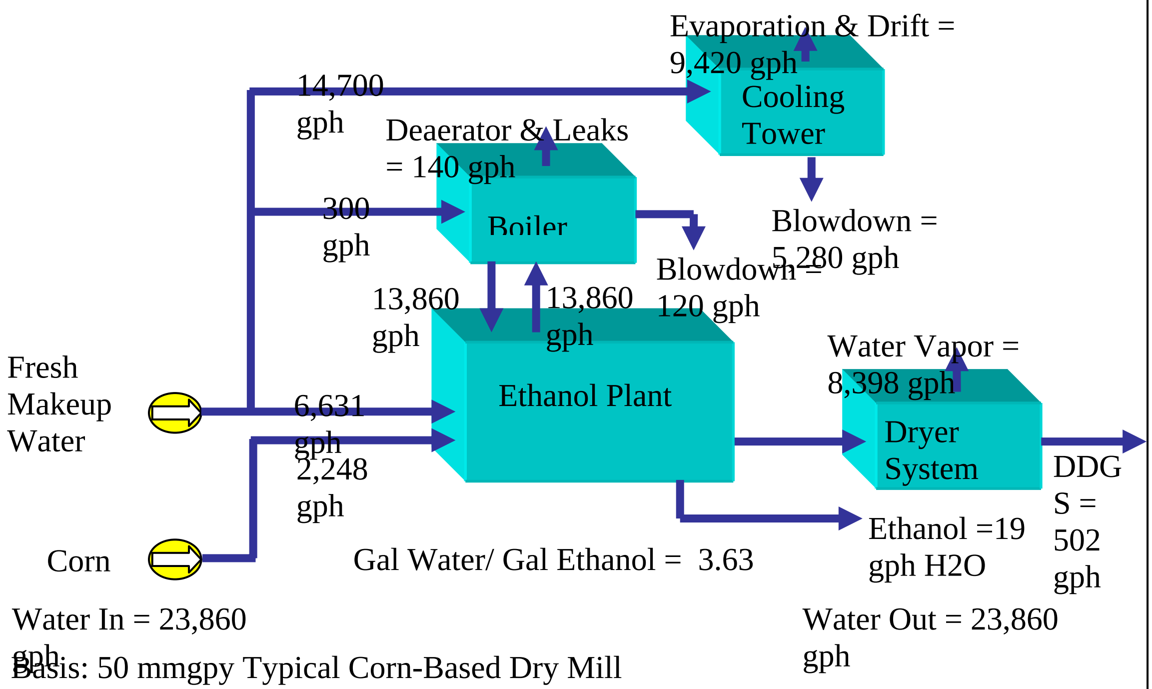
The largest non-technical challenge to siting ethanol plants will likely be non-governmental opposition. Currently, in many States ethanol plants are still largely seen as a positive form of development because of their economic impacts. However, as more and more communities obtain experience with operating plants, more problems are likely to become apparent, and some local opposition to any new plant should be expected. Proposals to construct ethanol plants in several states have already raised public concerns, if not opposition, because of the potential impacts of the plants on the local environment and communities. Environmental organizations have started to challenge some of these proposed plants, or even sue existing plants, over various environmental concerns.

In addition, a number of general concerns exist with respect to current ethanol production: the costs/benefits of using corn versus other plant crops for biofuels, air emissions (the USEPA currently charges that many ethanol plants are out of compliance with air laws), effects on the price of food (approximately 20 percent of the corn crop is now going for ethanol production), and even big business conspiracies (it is alleged that much of the current development of the ethanol industry is due to the lobbying efforts of Archer Daniels Midland to increase the demand for its agricultural products).

Ideally, water supply should be an important early technical factor in plant location selection. But because of the time and expense required to evaluate water supplies, typically groundwater, it is often pushed off with the implicit assumption that there will be sufficient water. Currently ethanol production requires from 2 to 4 gallons of water per gallon of ethanol produced. This is primarily used for process cooling water (see figure). The Dyersville plant will likely require between 550,000 and 1,100,000 gallons per day. Large plants can require in excess of 2,000,000 gallons per day: enough for a small city.

The impact of these plants on local water supplies is a significant concern for many communities. Efforts to find sufficient groundwater supplies to support an ethanol plant will likely include performing large scale pump tests to demonstrate that the plant's groundwater usage will not unduly impact existing and future groundwater supply needs for the surrounding community. The State of Minnesota is urging ethanol companies to be careful about where they site their plants because of water supply concerns. A plant recently built near Duluth is close to depleting its groundwater supply after less then a year in operation.

Overall Ethanol Plant Water Balance



Basis: 50 mmgpy Typical Corn-Based Dry Mill ethanol Plant

Source: http://www.ethanol-gec.org/information/Water-Conservation-Treatment-Strategies_Feb06.ppt