

STATEMAP
Winfield-BG

Bedrock Geology of Winfield Quadrangle

Calhoun County, Illinois

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Introduction

The Winfield Quadrangle is located in Calhoun County, Illinois, and contains parts of Lincoln and St. Charles Counties, Missouri. It is one of only a few places in Illinois where Lower Ordovician rocks outcrop at the surface, because of the effects of the Cap au Grès faulted flexure. In this spectacular structure, the rocks lie vertically as they continue into Winfield, Missouri, the locality after which the quadrangle was named. Glacially deposited materials are absent in the quadrangle, but a thick blanket of windblown loess covers the rugged uplands, making the land suitable for apple orchards, raising cattle, and other agricultural uses.

The quadrangle is located about 35 miles northwest of downtown St. Louis, Missouri and is bordered on the west by the Mississippi River. The major structural feature, the Cap au Grès faulted flexure, is a continuation of the Lincoln Anticline from Missouri, and is roughly on the border between the Ozark Dome on the west and the Illinois Basin on the east.

Mapping of the Winfield Quadrangle, along with the Brussels (Seid et al. 2008) and Grafton Quadrangles (Denny and Devera 2002), completes the mapping of the Cap au Grès faulted flexure at the 1:24,000 scale.

Mapping Methods

Some rock units have been lumped together for practicality in mapping at the 1:24,000 scale. For example, the Platin and Decorah Limestones have been mapped together because the Decorah is just 5 to 10 feet thick. Similarly, the three Silurian formations and the Devonian Cedar Valley Limestone have been mapped as one unit because the combined thickness of these units can be as little as 50 feet, and individual units are commonly absent. In addition, the Burlington and Keokuk Formations are so similar in lithology that they cannot be differentiated, and are mapped as a single unit. Lastly, the Warsaw and Salem Formations have been mapped together because only one outcrop of each formation exists within the quadrangle, and in only one locality was the contact between the two formations observed. The Pennsylvanian rocks were left undivided because outcrops were too scarce to make correlations over great distances.

In Calhoun County, an area of about six square miles in the eastern part of the quadrangle contains not one outcrop. Based on stratigraphic test cores taken within the adjacent Brussels Quadrangle (Hajic et al. 1991), loess thickness there varies from 30 to 65 feet within 3 miles of the banks of the Illinois River and a similar loess thickness probably is present in the Winfield Quadrangle. Only a few test holes or water wells have been drilled in the quadrangle. Due to the thick loess cover and vegetation, exposures are scarce in some areas, making important geologic features (faults and folds) hard to find and map accurately.

On this geologic map, formation contacts have been projected over large areas, although there are few outcrops that reveal the actual positions of contacts. For example, the Mississippian-Pennsylvanian contact was only observed in the Brussels Quadrangle at 460 feet elevation but was projected over about 10 square miles in the Winfield Quadrangle. Rubey (1952) took even greater liberties, projecting subcrops of poorly exposed or unexposed units across the entire map area. Since the loess cover can be extremely thick in some areas, bedrock units in some cases were mapped assuming about 20 feet of Quaternary deposits atop Paleozoic bedrock, except where field data allowed greater accuracy in determining the loess thickness. Since the loess cover can be extremely thick in some areas, bedrock units in some cases were mapped based on the formation that likely existed beneath the Quaternary cover. For example, the St. Louis Limestone is probably present at the bedrock surface where sinkholes are present south of the Cap au Grès faulted flexure. Similarly, Pennsylvanian rocks generally are present on the south side of Dogtown Hollow above 520 feet elevation and where steep slopes occur.

Rubey (1952) mapped a fault with about 30 feet of displacement with the north side downthrown based on dipping beds he observed in 1929 at the head of Greenbay Hollow, Sec. 34, T12S, R2W. When the current mapping was performed, there were no bedrock outcrops in the area to show evidence for a fault, but Rubey reported that it “is downthrown only about 40 feet on the north instead of on the south side” (1952, p. 142).

Gravel Deposits in Calhoun County

Rubey (1952) mapped a unit that he named the Grover Gravel of late Tertiary age on the uplands of Calhoun County. It is composed of well-rounded pebbles, cobbles, and boulders of purple, red, white, and black quartzite and chert. On Rubey’s 1:62,500 scale map, it is shown to vary in thickness from 0 to 20 feet. He concluded that the Grover Gravel was higher on the north side of the Cap au Grès faulted flexure than on the south side, indicating post-Tertiary movement on the Cap au Grès. In mapping the Winfield and Brussels Quadrangles, no gravel exposures were seen in place. Gravel was found along upland streams coming off of the Dividing Ridge in Calhoun County, but its elevation could not be determined. In Rubey’s map of the Hardin and Brussels Quadrangles (1952), and in Harrison’s map (1997), the Grover Gravel unit was mapped in many places over a large area, and this makes the unit appear much thicker than it probably is. No evidence was found in the current mapping that would allow accurate determination of the distribution, thickness, and elevation of the Grover Gravel. Lacking useable drill-hole data, there is no way to map the Grover Gravel accurately or to infer fault displacements based on its distribution.

The Mississippian-Pennsylvanian Unconformity

The contact between the Mississippian and Pennsylvanian

rocks in Calhoun County is sharp and unconformable. This contact marks the sub-Absaroka unconformity (Sloss 1963), an episode during which the Mississippian rocks underwent widespread erosion or non-deposition. The highest elevation where the St. Louis Limestone was found south of the Cap au Grès flexure in Calhoun County was found at 502 feet elevation, but it can be found at elevations as low as 450 feet. The topographic surface of the Mississippian rocks upon which the Pennsylvanian rocks were deposited is irregular. It would be valuable to know where areas of Mississippian rock have been extensively scoured by Pennsylvanian sandstones. A basal lag deposit with large rounded chert clasts and a coarse sand matrix was found to the east in the Brussels Quadrangle, sandwiched between the St. Louis Limestone and the Colchester Coal.

Stratigraphic Relations in the Pennsylvanian Strata

Mapping of the Pennsylvanian strata in the Winfield Quadrangle was performed in the winter of 2007–2008, when the absence of green foliage simplified locating outcrops. However, few Pennsylvanian outcrops were found, and other sources had to be used for mapping. Previous mapping by Rubey (1952) and unpublished field notes by H.R. Wanless and others who had worked in the area were extremely helpful in compiling the Pennsylvanian section and mapping the rock formations.

Pennsylvanian rocks only outcrop on the downthrown side of the Cap au Grès flexure in Calhoun County. Although exposures are scarce, correlations were made by John Nelson (ISGS) in the Brussels Quadrangle using the Colchester Coal as a marker bed. However, in the Winfield Quadrangle, there were no outcrops exposed. Therefore, the Colchester Coal could not be mapped reliably. In field notes by H.R. Wanless and others, the Colchester Coal occurred in the Brussels Quadrangle at elevations between 482 and 520 feet. The slight elevation differences, about 40 feet across a distance of several miles, could easily be due to minor warping of the strata. Exposures in the Brussels Quadrangle commonly did not reveal enough of the rock to measure the strike and dip of the layers.

The base of the Colchester Coal Member formerly was used to define the base of the Carbondale Formation in Illinois. Since 2001, however, the base of the Carbondale has been defined by the base of the Davis Coal Member (Tri-State Committee 2001). The Davis Coal was not observed in the study area. Directly overlying the Carbondale Formation, the highest Pennsylvanian rocks belong to the Shelburn Formation of the McLeansboro Group, according to current nomenclature. This nomenclature represents a significant change from that used by Rubey (1952). In the new terminology, the top of the Carbondale Formation is marked by the base of the Brereton Limestone Member (Tri-State Committee 2001). In the Winfield Quadrangle, the Herrin Coal was not observed, but it is not known to be absent. It reaches mineable thickness in the St. Louis Outlier, to the

southeast (W.J. Nelson, ISGS, personal communication 2008). Nelson provided correlations of three Pennsylvanian limestone benches in the Millstadt (Nelson 1999) and Freeburg Quadrangles (Nelson 2005) of Illinois and the St. Louis outlier of Pennsylvanian rocks, and his work suggests that the limestones and shales overlying the Colchester are dramatically thinned in this area. Unfortunately, no useful drilling records are available for this interval in the Winfield Quadrangle. With a drill hole through the coal seam, electric logs could be obtained and the Pennsylvanian section here could be carefully studied.

Economic Geology

Limestone

There are no documented limestone quarries within the quadrangle. However, the St. Louis Limestone is exposed along the bank of the Mississippi River from Beech Landing downstream to the eastern boundary of the quadrangle, and there is at least 68 feet of St. Louis Limestone at the mouth of Cache Hollow. The limestone resources are not lacking; rather, transportation difficulties from landlocked Calhoun County probably suppressed stone production (John Nelson, ISGS, personal communication 2008). However, limestone resources are ideally situated for barge transport.

The Kimmswick Limestone is a high-calcium limestone and is exposed near the surface over an area of about one and a half square miles north of Dogtown Hollow. It is about 70 feet thick in this area but is dipping about 3° northeast. South of the Cap au Grès, the Kimmswick dives deep down into the subsurface.

There are two factors which may obstruct stone quarrying operations. First, overburden consisting entirely of wind-blown loess deposits was observed to be as much as 60 feet thick atop the bedrock in Sec. 32, T12S, R2W. Second, the low elevation and close proximity of the limestone resources to the Mississippi River can be expected to cause large amounts of water to flow into any open pits that reach below current river level. For example, an abandoned quarry six miles east of the Winfield Quadrangle is filled with a large pond of water. This mine reveals that the St. Louis Limestone here extends below average river level, which is about 420 feet elevation. Any future mining below that level would require tremendous pumping to keep the working faces open.

Coal

There were no outcrops of coal observed during mapping of the Winfield Quadrangle, but based on observations in the adjacent Brussels Quadrangle (Seid et al. 2008), the Colchester Coal near the base of the Carbondale Formation here is two to three feet thick. There are no documented mine operations to date within the Winfield Quadrangle (ISGS County Coal Map Series), but a few mines were worked in the Brussels Quadrangle. The coal may have been strip mined locally by residents for personal use.

Oil and Gas

In the Winfield Quadrangle, the Cap au Grès flexure plunges to the east, exposing the oldest rocks in the quadrangle along the bluffs immediately north of Dogtown Hollow. The Ordovician Kimmswick (Trenton) Limestone is a generous oil producer in Illinois and Missouri along the Waterloo-Dupo Anticline. The Kimmswick is capable of trapping oil when confined by unbroken younger rocks in a structural anticline, but it has a small outcrop area in Sec. 29, T12S, R2W, and our mapping did not disclose any structural traps or other features that might be prospective for oil and gas.

Structural Geology

Cap au Grès Faulted Flexure

The Cap au Grès faulted flexure is a prominent structural feature that places Lower Ordovician strata within 1/5 mile of Mississippian St. Louis Limestone. The geometry of the folded rocks is monoclinial, with a gently dipping north limb and a steeply dipping south limb. The most intensely folded portion is at the mouth of Dogtown Hollow, where the Burlington-Keokuk Limestone is vertical. The outcrop pattern of the Ordovician formations north and east of Dogtown Landing reveals that the fold plunges to the east. The easternmost exposure of the Cap au Grès is in the Grafton Quadrangle (Denny and Devera 2002).

As it approaches the Mississippi River on the west side of the Winfield Quadrangle, the hinge line of the Cap au Grès fold turns to the northwest and becomes the Lincoln Anticline of Missouri. The Lincoln Anticline extends 165 miles northwestward into Missouri (McCracken 1971, p. 41) and is well exposed there.

Multiple Periods of Deformation

The Lincoln-Cap au Grès structure is a forced fold over a high-angle reverse fault in Precambrian crystalline basement (Nelson and Marshak 1996). The Cap au Grès has undergone many movements since the Precambrian (Rubey 1952), but the two major periods of movement were late Devonian and late Mississippian to early Pennsylvanian. The late Devonian movement was well-documented by Tikrity (1968). According to Kolata and Nelson (1991) and Nelson and Marshak (1996), "many of the Devonian faults [in the Illinois basin region] were active both prior to and subsequent to the Devonian, suggesting that they are long-lived crustal weaknesses." Movement of the Cap au Grès during the Devonian is evidenced by thickening of Devonian strata northward from the Cap au Grès, but no subsurface work has been done to study the Devonian on the downthrown side. Rubey (1952) mapped small outliers of Pennsylvanian atop the Burlington-Keokuk north of the Cap au Grès, about 10 miles north of the Winfield Quadrangle. One explanation of the thinning of the Pennsylvanian strata to the north is that continued uplift of the Cap au Grès during the deposition of Pennsylvanian rocks caused erosion or non-deposition on the upthrown side and thickening of deposits on the downthrown side. Addi-

tionally, the entire Mississippian Chesterian Series and the Pennsylvanian Caseyville Formation are absent. The absence of these rocks may reflect regional uplift of the Ozark Dome rather than localized uplift of the Cap au Grès structure.

The Colchester Coal is the only coal present in the area, suggesting that the area was near sea level during deposition of at least that part of the Carbondale Formation. Therefore, it is possible that the Cap au Grès was a topographic high at the time when Pennsylvanian seas flooded the low areas on the sub-Pennsylvanian surface.

Fold Geometry

The Cap au Grès seems to be most intensely deformed at its endpoints. For example, in the Brussels Quadrangle, 3900'WL, 100'SL, Sec. 11, T6N, R13W, the south limb is overturned. In the Grafton Quadrangle, there is 1000 feet of displacement (Denny and Devera 2002). In Dogtown Hollow, the dip of the Burlington-Keokuk Limestones is vertical, and Lower Ordovician rocks are present only about 1000 feet from the Mississippian St. Louis Limestone. On the contrary, near the mid-point of the hinge line of the Cap au Grès fold, the strata are much less deformed. For example, at the mouth of Greenbay Hollow in the Brussels Quadrangle, the steepest dip was in the Burlington-Keokuk Limestones, as beds dip 25° to the south. Thus, the Cap au Grès apparently relaxes around its midpoint where it is concealed by thick Quaternary sediments along the Illinois River. This may suggest that a change in the orientation of an uplifted basement block at the junction of the Cap au Grès and the Lincoln Anticline contributes to the complexity of the structural geometry of the Cap au Grès at its western end.

At Dogtown Landing, there is a small fault in the Warsaw and Salem Formations, as beds that dip 62° south are adjacent to beds that dip 28° south. Similarly, there is a small fault in the beds of the Burlington-Keokuk Limestones, as beds that dip 61° south are then vertical in a short distance. These observations suggest the presence of faults with small offsets within these formations. These faults are probably not through-going and are simply small adjustments or accommodations to the main fold. Such faults occur in grainstone facies of limestones, suggesting that grainstone lithologies accommodated the stresses by faulting and folding. Less competent units such as the Hannibal Shale and Maquoketa Formation are squeezed along the axis of the fold.

Cross sections A-A', B-B', and C-C' reveal the subsurface structure along the Cap au Grès at different points along its length. The fold is gentler in A-A' than it is in C-C', indicating that the geometry of the flexure changes along its length.

Magnetic and gravity anomalies exist across the Cap au Grès. A small magnetic anomaly exists in the Brussels Quadrangle in Sec. 11, T6N, R13W (Devera and Denny 2000), which correlates with the Deer Lick Dome (Rubey 1952). Fifteen miles southeast of there, an even larger magnetic anomaly

occurs in St. Louis, Missouri, called the Florissant Dome (McCracken 1971). A drill hole near the Florissant Dome hit basement at 2633 feet below mean sea level, according to records obtained from the Missouri Geological Survey.

Mateker (1956) performed a gravity survey of the Cap au Grès that indicated a vertical displacement of 1100 feet and a depth to basement of 3000 to 3100 feet. The geophysical data indicate that the Cap au Grès is a rejuvenated Precambrian fault in the underlying basement (Mateker and Segar 1965, *in* Tikrity 1968). A magnetic survey of the Cap au Grès performed by Douthit (1959) agreed with Mateker.

Are There Any Strain Markers?

In a zone of intense deformation, such as the Cap au Grès, geologists commonly try to identify strain markers such as elongated pebbles, stretched fossils, or other objects whose normal dimensions have been altered. However, no strained fossils or elongated grains have been identified by the authors. Rubey did not understand why strata are folded abruptly but are seldom fractured. Additionally, he found it difficult to understand “why beds of brittle limestone under such a light load of superincumbent strata should have been deformed by folding rather than by breaking and brecciation.” The most probable solution was offered by Stephen Marshak of the University of Illinois (personal communication 2008)—that the strain rate was too low to break the beds in most places. Further, the grade of deformation was too low to develop foliations.

Mechanisms of Faulting and Folding

Mid-continent faults were initiated during the late Precambrian (Marshak, personal communication 2008) under transtensional stresses, creating a grid of normal faults. When Paleozoic stress fields were applied, this pre-existing grid of jostled blocks was reactivated. McBride and Nelson (1999) related the Cap au Grès flexure and many other folds in Illinois and eastern Missouri to the Ancestral Rocky Mountains orogenic event. They concluded that the Cap au Grès faulted flexure is a drape fold over one of these pre-existing faults in the Precambrian basement, similar to the Laramide style monoclines in the Western United States. It is probably a high angle reverse fault. McCracken (1971, p. 3) made a general statement referring to the entire state of Missouri that “folding, in many cases, may not be so much a result of lateral stress as it is a result of sedimentary rocks draping over a block-faulted Precambrian basement of competent crystalline rocks.”

Troy-Brussels Syncline

Rubey (1952) mapped the Troy-Brussels Syncline, which parallels the south limb of the Cap au Grès flexure, and called it “an extremely asymmetric syncline that plunges eastward...more steeply in the eastern than in the western part of the area.” He interpreted that strata dip gently north-eastward off the Ozark Dome. Although recent mapping does not support a syncline, Rubey identified the syncline by

deep drill holes in Grafton, Illinois and Orchard Farm, Missouri along with the few available exposures in southern Calhoun County in 1928–1929. Rubey believed that the failure to find minor flexures along the Troy-Brussels Syncline “is the result of an actual absence of these minor flexures and a real difference in the type of deformation north and south of the Cap au Grès flexure.” About ¼ mile south of Dogtown Landing, the dip of the beds of the St. Louis changes from 6° to more than 20° southward within only a few feet of horizontal distance. There was no evidence south of there that the St. Louis dipped toward the north, and therefore, the Troy-Brussels Syncline could not be identified by the author. Its existence is not in question because in Missouri, the Troy-Brussels Syncline trends northwest, parallel to the Lincoln Anticline. However, due to thick Quaternary deposits, dipping beds are hard to find in the Winfield Quadrangle.

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