Wisconsin Geological
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DIVISION OF EXTENSION
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Supplemental report on the geologic map of the Bloomington and Brodtville 7.5-minute quadrangles, Grant County, Wisconsin

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Introduction

The Brodtville and Bloomington 7.5-minute quadrangles are located in the Driftless Region of southwestern Wisconsin, an unglaciated region with a relatively thin Quaternary cover. Military Ridge, a prominent east–west, low-relief ridge with undulating topography, crosses the north-central portion of the two quadrangles. Military Ridge represents a major drainage divide between watersheds flowing northward into the Wisconsin River and watersheds flowing south and west into the Mississippi River. Flat-bottomed stream valleys have incised into upland ridges, and relief between uplands and valleys can exceed 450 feet.

The Brodtville and Bloomington quadrangles are underlain by Lower to Middle Ordovician siliciclastic and carbonate strata. The Ordovician section is largely undeformed with the exception of well-developed joint systems. The Mineral Point anticline is the only map-scale structure of note in the map area, and it passes through the extreme northeastern edge of the Bloomington quadrangle.

Mapping was initiated to develop a three-dimensional geologic framework for groundwater contamination studies in the Grant County area. Many groundwater wells in southwestern Wisconsin contain elevated concentrations of nitrates and coliform bacteria (M. Borchardt, J. Stokdyk, K. Bradbury, K. Abbott, L. Schweikert, and T. Loeffelholz, U.S. Geological Survey and Wisconsin Geological and Natural History Survey, written commun., 2019). Three-dimensional surfaces of unit contacts can help determine which geologic units contribute water to groundwater wells. Secondary goals for mapping included locating springs and seeps and documenting their location within the stratigraphic section. The Brodtville and Bloomington quadrangles were chosen for 1:24,000-scale mapping in part due to the lack of bedrock folds and faults in the area (with the exception of the Mineral Point anticline), providing a good opportunity to characterize important hydrostratigraphic surfaces without structural interference.

Sources and Methods

Data sets used in constructing contacts on the map plate included field observations, lithologic logs from well construction reports, and landforms visible from a lidar-derived digital elevation model (DEM). Rasters (3D surfaces) of unit contacts are included in the Supplementary Material. Rasters were created by drawing contact polylines in ArcMap, then converting polylines to points and calculating elevations derived from the lidar-DEM for each point. Rasters were constructed with the Topo to Raster tool using the point-contact elevations combined with subsurface contact elevations from well-construction reports. Additional details on well-construction report uncertainty are given in Stewart and others (2022).

Prior bedrock work in the area includes regional mapping by Strong (1876) and Grant (1906). Quaternary geology of Grant County was mapped by Carson (2012) at 1:100,000. The Beetown mining district, located just south of the Bloomington 7.5-minute quadrangle, was mapped by Heyl and others (1952) at a scale of 1:12,000. Bedrock units use the classification scheme of Agnew and others (1956) and Stewart and others (2022). This classification places the Ion member within the Decorah Formation and treats the New Richmond as a formation within the Prairie du Chien Group, which differs from Wisconsin Geological and Natural History Survey (2011).

Hydrostratigraphy

Secondary porosity

Many groundwater wells in Grant County contain elevated concentrations of nitrates and coliform bacteria (M. Borchardt, J. Stokdyk, K. Bradbury, K. Abbott, L. Schweikert, and T. Loeffelholz, U.S. Geological Survey and Wisconsin Geological and Natural History Survey, written commun., 2019). Transmission of these surface contaminants into aquifers is influenced, in part, by the concentration of joints, vugs, and other types of secondary porosity in bedrock units. Secondary porosity can vary within and between geologic map units. Interconnected secondary pore space can lead to high groundwater flow in units where matrix permeabilities are low. Recognizing stratigraphic intervals with elevated secondary porosity is useful for understanding where surface contaminates might quickly enter drinking water sources.

Secondary porosity was estimated in the field by calculating the number of fractures and vugs that intersected bedding-parallel transects. Values were normalized per meter. Measurements were taken along two measured stratigraphic sections in the northwestern portion of the Brodtville quadrangle within the Ancell and Sinnipee Groups (locations given on figure 1). Values from the measured section (figure 1) were combined with outcrop estimates from across the Brodtville and Bloomington quadrangles and plotted in figure 2 as a box and whisker plot.

Most fractures are believed to originate from tectonic stresses rather than unloading. Fracture populations in the Brodtville and Bloomington quadrangles and across southwestern Wisconsin show dominant orientations parallel and perpendicular to regional fold axes (Heyl and others, 1959; Stewart and others, 2022). Unloading can cause rock fracturing related to the near-surface stress field, but due to the consistent fracture populations observed in the Brodtville and Bloomington quadrangles, it is likely that unloading simply reactivated preexisting tectonic fractures rather than creating new ones. This could affect groundwater because fracture apertures in the deeper subsurface may be lower than what is present in outcrop due to loading effects. Fracture density measured in the Galena Formation is marginally higher than other carbonate units. Despite thicker bedding, the Ion Member of the Decorah Formation and the Pecatonica Member of the Platteville Formation do not have noticeably lower fracture densities than the McGregor Member of the Platteville Formation and the Guttenberg Member of the Decorah Formation (figure 1).

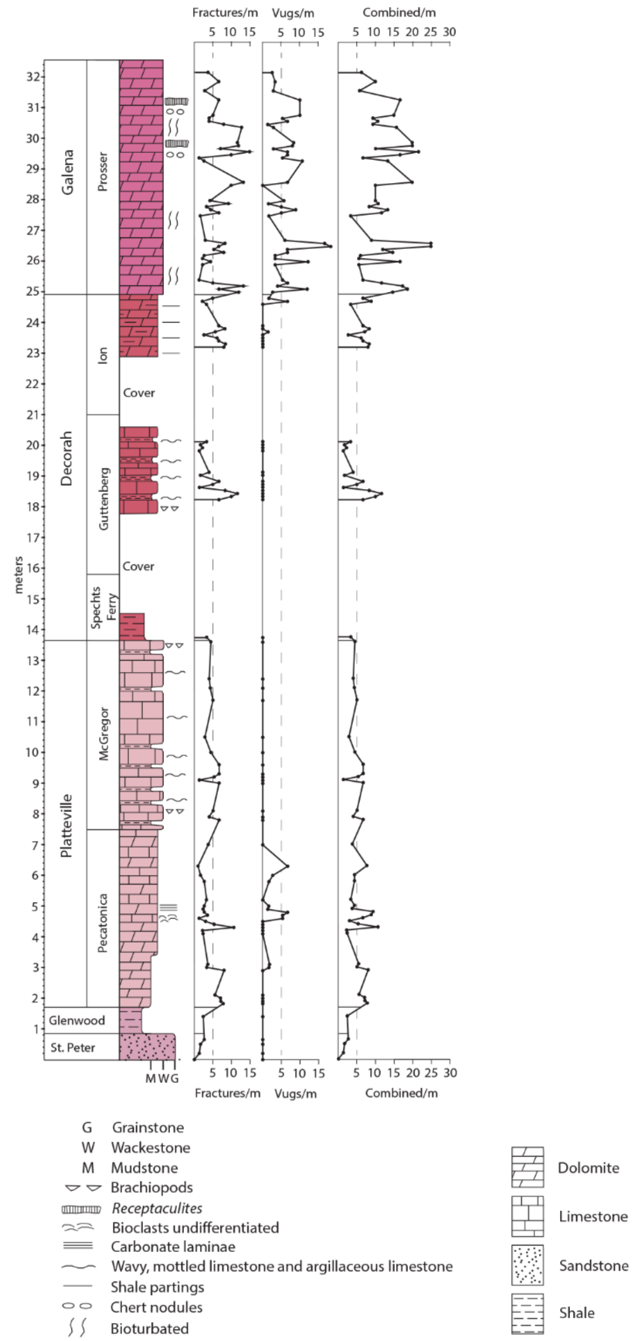

Figure 1. *Hybrid measured stratigraphic section. The Guttenberg Member through the Galena Formation section was measured at NAD83 15T 0653121; 4761859, and the St. Peter Formation through the Spechts Ferry Member section was measured at NAD83 15T 0654396; 4760889. The Quimbys Mill Member of the Platteville Formation was not observed in outcrop. It is possible a thin Quimbys Mill Member is present but was missed due to discontinuous exposure below the Decorah Formation.*

Vug density and combined vug/fracture density measured at the surface is much higher in the lower Galena Formation than in other units (figures 1, 2), and this is probably caused by the presence of *Thalassinoides*. *Thalassinodes* is a trace fossil assemblage containing crossing, interconnected horizontal burrows that can also be connected vertically. The vuggy texture causing the distinctive honeycomb surface appearance of the Galena Formation has been interpreted to be the result of differential weathering and solution enhancement at the surface of lithofacies within the Galena Formation containing *Thalassinoides* burrows (figure 3, Beyer and others, 2008). Solution enlargement of carbonate porosity is greatest at the surface, and so the size and density of vugs is generally greater at the surface than in the subsurface. Figures 1 and 2 do not suggest that the Galena Formation contains similar vug density in the subsurface; rather, measured vug density at the surface is probably a rough proxy for the density of *Thalassinoides* in the subsurface.

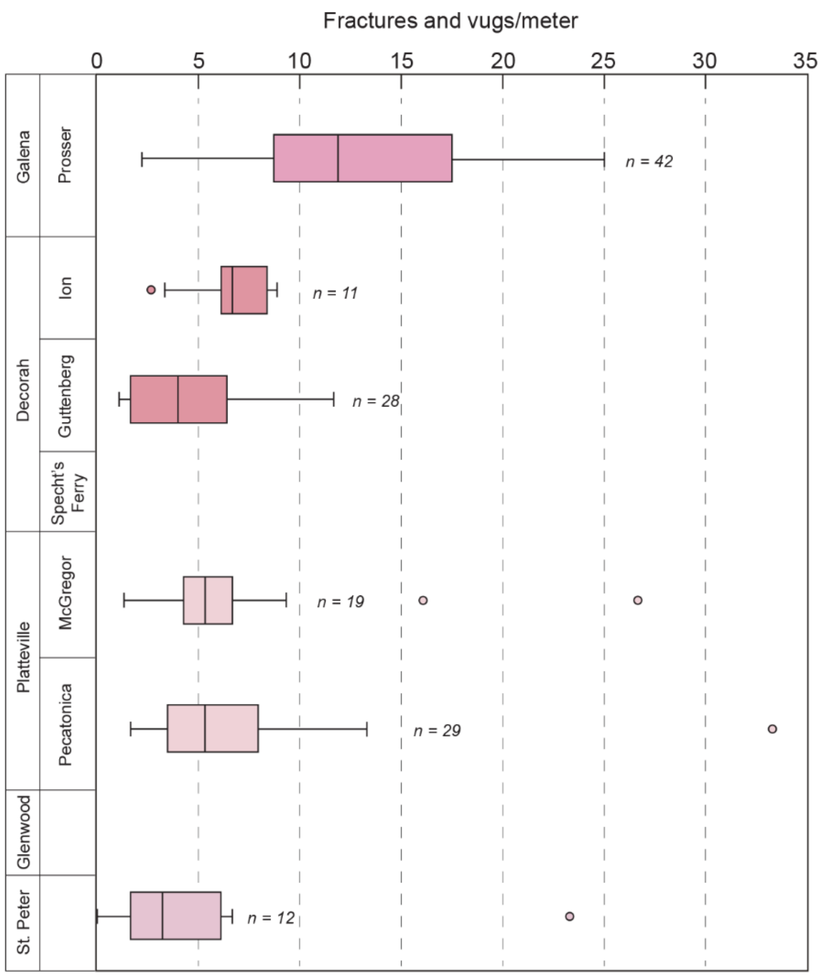

Figure 2. *Box and whisker plot of combined vug and fracture density per stratigraphic unit. The middle line within each box marks the median. The box width marks the range of values between the median of the lower half of the data (25th percentile) and the median of the upper half of the data (75th percentile). Outlier points represent data points greater than 1.5 times the interquartile range (75th percentile–25th percentile). The Quimbys Mill Member was not observed in outcrop.*

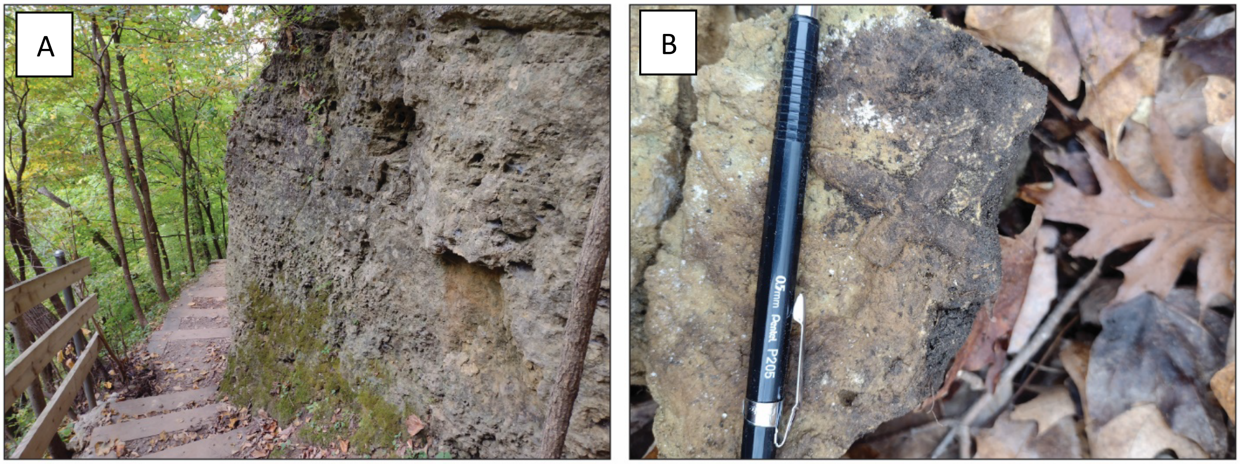

Figure 3. *Panel A shows the typical vuggy surface appearance of the Galena Formation, Wyalusing State Park. Vugs at the surface form from solution enhancement of burrow networks. In panel B, intersecting* Thalassinoides *burrows (right of pencil). Looking at the underside of a Galena Formation bed, near the base of the unit, Wyalusing State Park.*

When interconnected over lateral distances significant for groundwater flow, *Thalassinoides* burrow networks can lead to important changes in bulk permeability even without significant solution enhancement. Unweathered samples of rocks from the Galena Formation that include *Thalassinoides* burrows show different textures within the burrows as compared to the surrounding matrix. Dockal (2021) reported that *Thalassinoides* burrows in the Galena Formation contain a coarser grain size, higher porosity, and greater permeability than the surrounding matrix. These textural and hydrogeologic differences probably lead to the differential weathering and honeycomb appearance of the Galena Formation at the surface. Not all lithofacies within the Galena Formation contain *Thalassinoides* (Beyer and others, 2008), which could give rise to heterogeneity in hydrogeologic properties in the subsurface. Elsewhere, carbonates with abundant interconnected *Thalassinoides* burrows have been found to significantly increase permeability and flow as compared to beds containing non-burrowed carbonate matrix (Golab and others, 2017; Knaust and others, 2020; de Araújo and others, 2021; Eltom and others, 2021).

Springs

Stratigraphic horizons containing springs and seeps are useful to document because they often form at the contact between an overlying aquifer and an underlying aquitard. Aquitards restrict vertical groundwater flow and increase horizontal groundwater flow. This often leads to springs along valley slopes at consistent stratigraphic locations.

Spring locations were compiled from Swanson and others (2019) and from field observations during mapping in the Brodtville and Bloomington quadrangles, as well as in adjacent quadrangles to the north and east (figure 4).

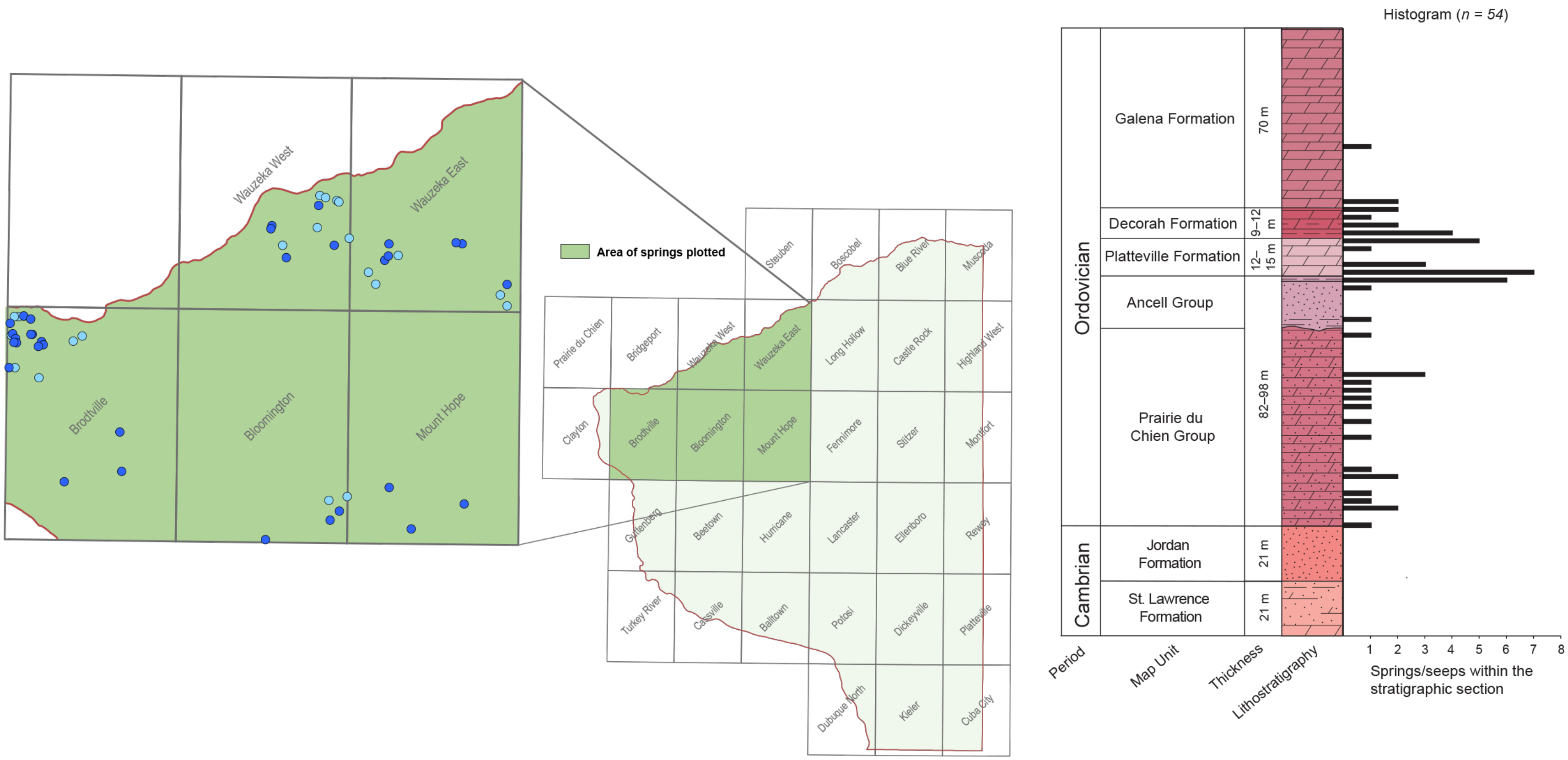

Figure 4. *Map showing spring (dark blue circles) and seep (light blue circles) locations in northwestern Grant County, and their position within the stratigraphic section. Each histogram bin is 3.05 m (10 ft).*

The stratigraphic locations of springs and seeps were calculated by comparing the elevation of the spring or seep to the elevation of the base Platteville Formation in the Brodtville and Bloomington quadrangles as well as reconnaissance mapping nearby. A raster of the base Platteville Formation is available in the Supplemental Materials, as well as location information for springs, seeps, and outcrop control. Damp areas with evidence for past flow were classified as seeps, and areas with flowing water coming out of the ground were classified as springs. Most springs and seeps in the Decorah and Platteville Formations were observed along valley slopes or in steep tributary streams, while most springs in the Prairie du Chien Group were observed in the flat valley bottoms.

Spring and seep horizons (n = 54) are concentrated above the Glenwood Formation and the Spechts Ferry Member of the Decorah Formation (figure 4). Both of these units contain shale intervals in excess of 0.5 m (2 ft). Scattered springs and seeps also occur throughout the Ion and Guttenberg Members of the Decorah Formation, as well as the Prairie du Chien Group.

Few springs occur in the Galena Formation, and this may relate to its lithologic characteristics. The contact between the Galena and the underlying Decorah Formation corresponds to a significant change in shale content and secondary porosity observed at the surface (figures 1, 2). The transition from vuggy Galena to less vuggy Decorah Formation may correspond to a reduction or loss of *Thalassinoides* burrows in the stratigraphic section. Combined with a higher shale content in the Decorah Formation, this could be driving the change from few springs in the Galena to more springs in the upper Decorah Formation. The full thickness of the Galena Formation is not present in the map area, and much of the Galena Formation present is above the water table. Additional spring horizons would probably occur in the Galena Formation if more section was present.

Supplemental material

In addition to this report, GIS data are available for download from the WGNHS Publication Catalog (https://doi.org/10.54915/mcau3924).

Dataset 1: GIS data for the geologic map of the Bloomington and Brodtville 7.5-minute quadrangles, Grant County, Wisconsin
Includes raster datasets of the base of the Ancell Group, base Platteville Group, base Decorah Formation, and base Galena Formation. Also includes feature classes of unit contacts, field data, well-construction reports, and polygons of map units. Data are in file geodatabase (.gdb) format.

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