Wisconsin Geological
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DIVISION OF EXTENSION
UNIVERSITY OF WISCONSIN–MADISON

Supplemental report on the geologic map of the Fennimore and Mount Hope 7.5-minute quadrangles, Grant County, Wisconsin

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Sarah E. Bremmer[a], Eric D. Stewart[a], William G. Batten[a], Allison R. Kusick[a,b], Natalie McNall[a,b]

[a]Wisconsin Geological and Natural History Survey
[b]Department of Geosciences, University of Wisconsin–Milwaukee

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Contents

Introduction

This map provides surface and subsurface geologic information for the Fennimore and Mount Hope 7.5-minute quadrangles. The Fennimore and Mount Hope 7.5-minute quadrangles are located in the Driftless Region of southwestern Wisconsin. The Driftless Region is an unglaciated portion of the state with relatively thin Quaternary cover (Chamberlin and Salisbury, 1886). The landscape is marked by a series of upland plateaus and flat-bottomed stream valleys with relatively steep valley walls. Relief between uplands and valleys commonly exceeds 200 ft (61 m). Military Ridge, running roughly east-west across the northern portion of the two quadrangles, is the largest upland plateau in the area. The northeastern and eastern sections of the Fennimore quadrangle lie within the northern boundary of the historic Upper Mississippi Valley lead-zinc mining district (Agnew and others, 1956; Heyl and others, 1959).

Mapping was initiated to support groundwater studies in the area (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). No recent geologic maps of the Fennimore or Mount Hope quadrangles exist, and none exist at the 1:24,000 scale. This map builds on, and refines, the previous mapping of Heyl and others (1959). This map and accompanying report present the lithologic and physical properties of the Paleozoic bedrock units, as well as geologic structures present in the area. Combined, this knowledge can be used as a tool to better understand groundwater quality and quantity both locally and regionally.

Methods

Traditional field methods were used to construct the map, augmented with well construction reports (WCRs), geologic logs derived from water-well cuttings, mineral development atlas (MDA) logs (Pepp and others, 2019), surficial geoprobe cores, and bedrock drill cores. Three new cores were drilled for this project in Croft Quarry, west of Fennimore, Wisconsin (fig. 1): Croft Quarry core 1 (WID #22000428), Croft Quarry core 2 (WID #22000429), and Croft Quarry core 3 (WID #22000430). Full descriptions of these cores are presented in appendix 1 and in dataset 1.

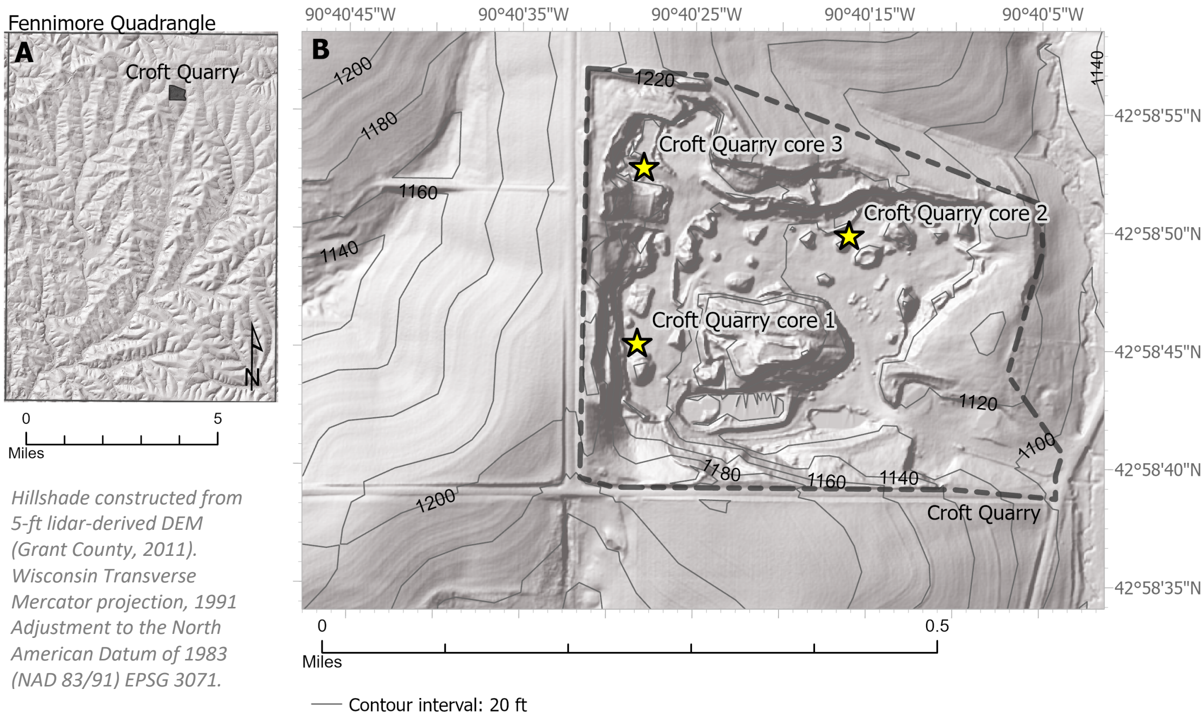

***Figure 1**. Panel A, location of Croft Quarry within the Fennimore 7.5-minute quadrangle. Panel B, yellow stars indicate the location of the three new WGNHS cores collected in this project and used to create this map. The coordinates of these cores are provided in dataset 1.*

A structure-contour map of the base of the Sinnipee Group (base of Platteville Formation) (figs. 2–3) was constructed from surface mapping of outcrops, mapping using Lidar, three bedrock cores, seven geologic logs, 10 MDA logs, and 134 WCRs. The base of the Sinnipee Group was used due to the higher confidence in picking that surface in WCRs and MDA logs, its good exposure in the field area, and scarp-forming geomorphology. Fold and fault traces (fig. 2) were interpreted from the structure contour map.

Structure

The Fennimore and Mount Hope quadrangles are situated on the broad sloping flank of the Wisconsin dome, centered in north-central Wisconsin, N-NE of the map area. Paleozoic strata have small regional dips approximately southward (Heyl and others, 1959). To the east of the map area, is the N-S-trending Wisconsin arch, which is likely a composite feature resulting from Precambrian structures (Stewart, 2021; Stewart and others, 2022) similar to the NE-SW-trending Transcontinental Arch (Carlson, 1999; Runkel and others, 2007) west of the map area. Other significant regional structures include the Forest City Basin to the west, and the Illinois Basin to the South (Heyl and others, 1959). Locally, the entire Paleozoic section is weakly deformed into gentle folds with variable amplitudes and orientations.

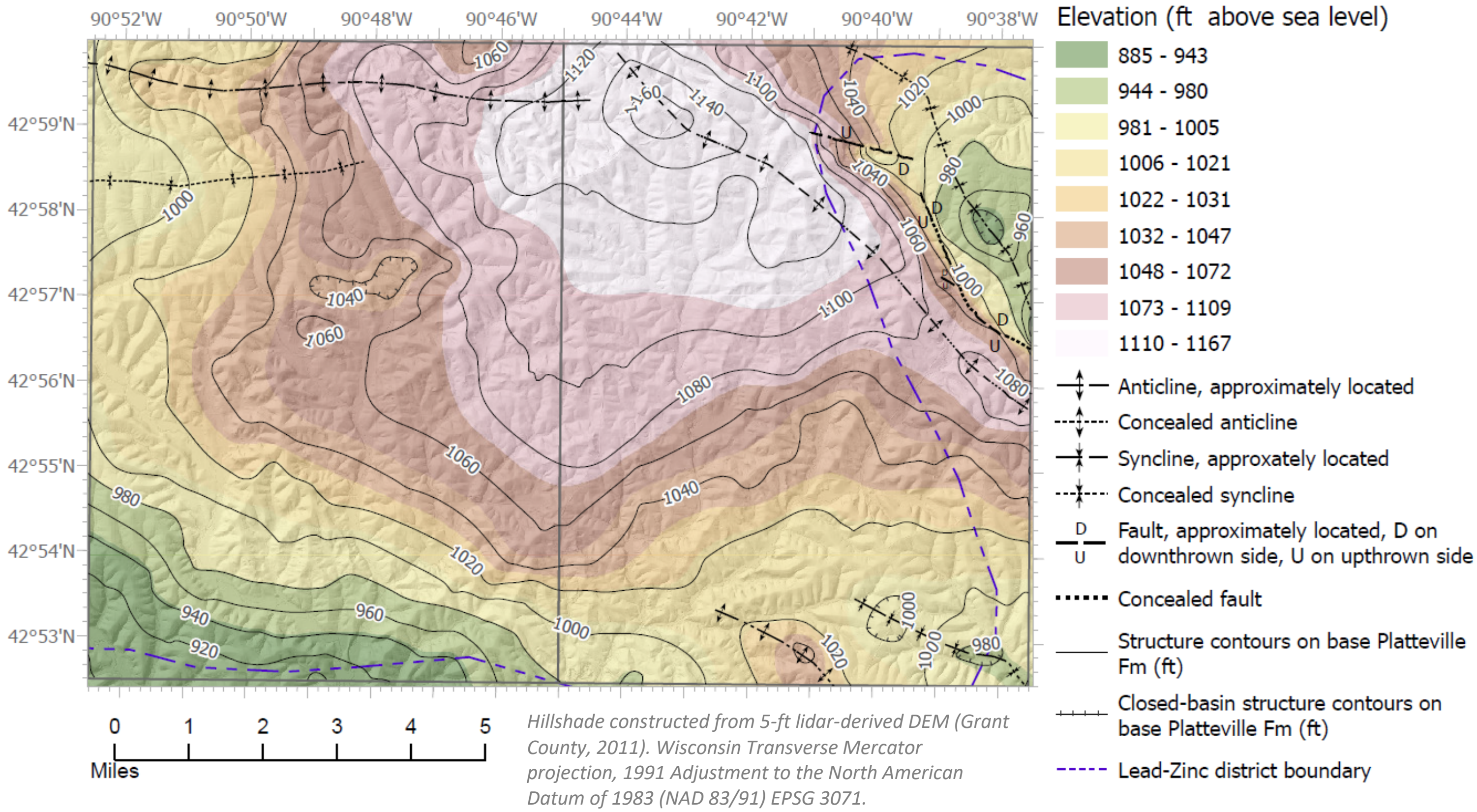

***Figure 2**. Structure contour map for the base of the Platteville Formation and interpreted structures in the Mount Hope (left side) and Fennimore (right side) 7.5-minute quadrangles, Grant County, WI; 20-foot contour interval.*

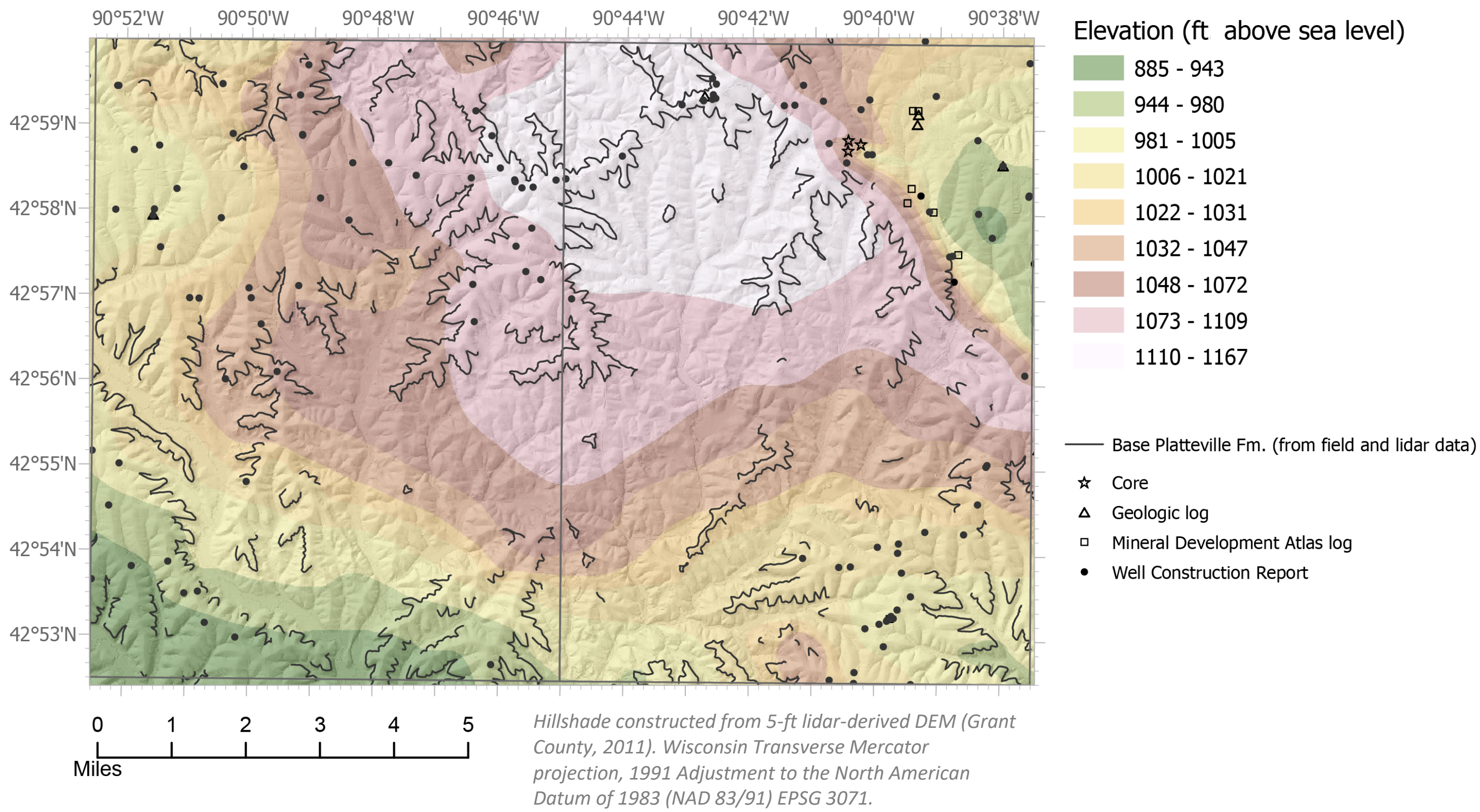

Figure 3. *Sources used to construct the base Platteville Formation structure contour map in figure 2 from the Mount Hope (left side) and Fennimore (right side) 7.5-minute quadrangles. Data include surface mapping in the field and using Lidar (lines), cores (black stars), geologic logs (black triangles), mineral development atlas logs (black squares), and well construction reports (black dots).*

Folds

Mineral Point anticline and Annaton syncline

The Mineral Point anticline is the most prominent structural feature in the map area. It forms a northwest-southeast trending, asymmetric, oblong dome with a maximum amplitude of approximately 130 ft (39 m) centered in northwest Fennimore quadrangle. The northeastern side of the dome is steeply dipping to the northeast while the southwestern side is gently dipping southwesterly. The Mineral Point anticline narrows in west-central Fennimore quadrangle.

The Annaton syncline is present northeast of the Mineral Point anticline (see map). It forms a basin that trends parallel to the steep side of the anticline, with a maximum amplitude of approximately 100 ft (30 m) in the northeast region of the Fennimore quadrangle.

Minor folds

Smaller, subtler folds, with maximum amplitudes of 30 to 50 ft (9 to 15 m) are also observed in the map area; the most prominent are marked on the map. In the northern portion of the Mount Hope quadrangle small folds trend approximately east-west. The most northern is a roughly symmetric anticline that intersects the Mineral Point anticline. In southeastern Fennimore quadrangle the folds trend approximately northwest-southeast.

Faults

The steep, northeast limb of the Mineral Point anticline is heavily fractured and likely cut by several small-scale faults. Tens of feet of offset were observed across short lateral distances (250 to 500 m) on the base Sinnipee Group surface along this steeper, northeastern limb. The Croft and Gregory Branch faults, discussed below, are mapped based on the observed offsets on the base Sinnippee Group surface. At the scale of this map, these faults are drawn as single lines; however, they may actually be a series of small faults rather than one single fault. The observation of the Croft and Gregory Branch faults contrasts with the interpretation of Heyl and others (1959), who mapped a single, through-going, 18.5-km-long (11 mi) reverse fault striking roughly parallel to the Mineral Point anticline.

Croft fault

The Croft fault is located east of the town of Fennimore, WI, and strikes approximately east-northeast, west-southwest for approximately 1.4 miles (2,290 m; see map). This fault was first recognized through mapping the offset of the Galena Group and Decorah Formation contact in Croft Quarry. The southern side of the quarry is down-dropped relative to the northern side. Direct observation of the fault surface was not found in outcrop. Subsequent bedrock coring for this work within the quarry (figs. 1, A1.1–A1.3) supports surface mapping of offsets in the unit contacts, and surface observations of brittle deformation. For example, Croft Quarry cores 2 and 3 contain small normal faults in the Prairie du Chien group through McGregor Member. No large fault surface was observed in the cores, despite cores 2 and 3 being closely spaced. This supports the notion that these regions are cut by a series of small faults. If there is a single through-going fault in the quarry, it is steeply dipping (greater than or equal to 82°).

Based on kinematic indicators in the cores and the possibility of a steeply dipping fault surface, we interpret Croft fault to have normal offset with a maximum throw of approximately 50 to 55 ft (15.2 to 16.7 m) near the southeastern segment of the fault. The down-dropped southern block forms a basin-like structure.

Gregory Branch fault

Gregory Branch fault is located southeast of the Croft fault and trends north-northwest, south-southeast for approximately 1.8 miles (2.9 km), primarily through the river valley where U.S. Highway 61 is located, then curves eastward into the neighboring Stitzer 7.5-minute quadrangle.

The Gregory Branch fault was recognized through mapping the offset along the contact between the Platteville Formation and the Ancell Group. This was primarily done by examining outcrops in the Gregory Branch river valley along U.S. Highway 61 between Pine Grove Rd and McGhan Rd. In this valley, the eastern side is down-dropped relative to the western side, which forms a small basin-like structure. The maximum throw is approximately 50 to 60 ft (15.2 to 18.3 m) near the center of the fault. Again, no fault surface was directly observed in outcrop.

Fault type (reverse, normal, strike-slip), fault dip direction, and dip angle are unconstrained, but we suggest this is another steeply dipping normal fault (or series of faults) based on similar geometry, scale, and proximity to the Croft fault.

Minor faults

A small fault is located just east of the Gregory Branch fault on the west side of U.S. Highway 61 (see map). This fault trends northeast-southwest for approximately 650 ft (200 m). Maximum throw is 20 ft (6 m). This fault is interpreted to be a steeply dipping normal fault, however its exact orientation is unconstrained by direct observation.

In the southeast corner of the Fennimore quadrangle a fault trending NW-SE was observed in a roadcut along U.S. Highway 61. Slicken fibers indicate primarily right-lateral sense of offset with a minor component of dip-slip motion, northeast side down. Heyl and others (1959) mapped a 1.2-mi-long (2 km) reverse fault in in this area with the same northwest-southeast trend. This fault is not included on the map, as its extent could not be constrained with field or subsurface data.

Joints

Joint orientations in the Tonti Member of the St. Peter Formation differ from joint orientations in the overlying Sinnipee Group and underlying Prairie du Chien Group (fig. 4). Joints in the Tonti Member show a more distributed population of joints with a roughly equal percentage of

E-W-, WNW-ESE-, NNE-SSW-, and NE-SW-striking joints. Joints in the Sinnipee Group show a dominant NE-SW-striking population with a distributed population of NW-SE-striking joints. Joints in the Prairie du Chien Group show approximately three dominant orientations: NE-SW-, NW-SE, and E-W-striking.

Increased brittle deformation is observed proximal to mapped folds and faults and smaller-scale undulations in the Base Sinnipee Group surface. In these areas, outcrops display an increase in number of joints across the outcrop as well as localized zones of densely packed joints, commonly 1 to 4 ft (0.3 to 1.2 m) in width. Deformations bands in the Tonti Member locally common.

Most joints observed in outcrop display no obvious indicators of shear movement with the exception of a few outcrops in the zones of increased brittle deformation. At a few outcrops in these zones, cross-cutting conjugate joints, suggesting minor amounts of shear, were observed, but kinematic indicators were not found. Poorly-developed slickenlines were only observed within the Sinnipee Group along a few, approximately vertical joints, indicating minor vertical (dip-slip) movement.

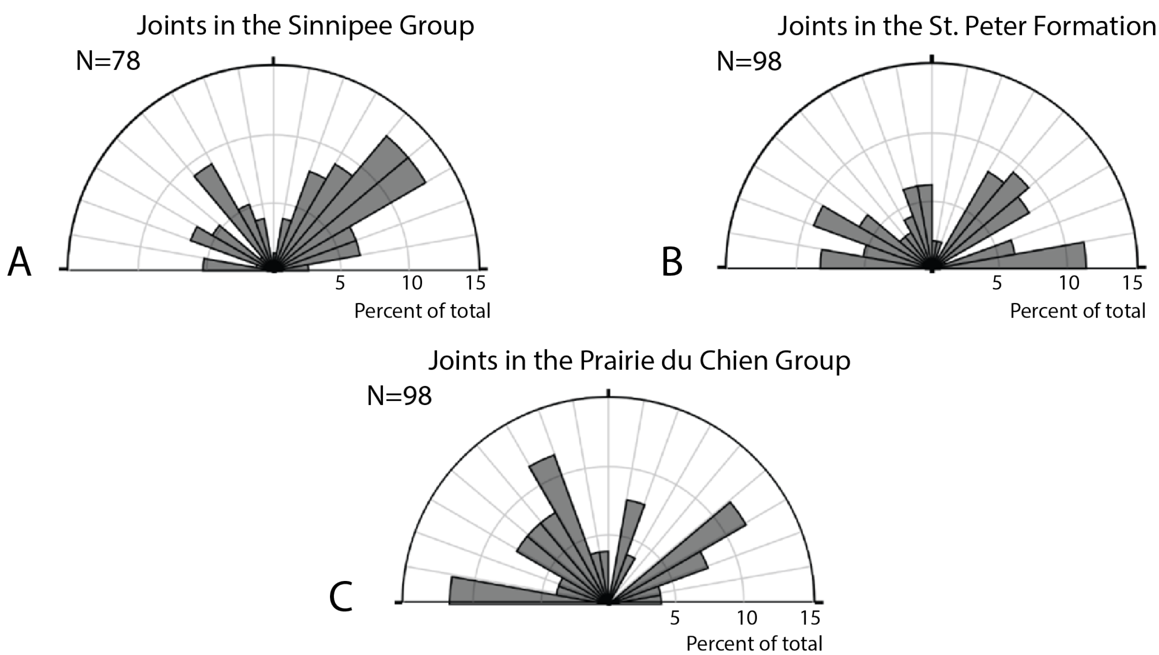

***Figure 4**. Half-circle rose diagram showing orientations of joints measured in the field. Bin orientations reflect the strike direction. N is the number of measurements. Panel A, joints measured in the Sinnipee Group (Galena, Decorah, and Platteville formations). Panel B, joints measured in the Tonti Member of the St. Peter Formation. Panel C, joints measured in the Prairie du Chien Group.*

Interpretation

Heyl and others (1959) interpret the structures in the map area to be a result of lateral tectonic compression associated with the Appalachian and Oachita orogenies during the late Paleozoic, solution thinning, and structures in the underlying Precambrian basement rocks. Our observations build on the work of Heyl and others (1959), although we did not observe solution thinning, and are consistent other studies documenting that structures in the Precambrian basement rocks strongly influenced deformation of the Paleozoic rocks (e.g. Stewart 2021; Steenberg and others, 2015).

The folds in the map area are interpreted to be forced folds (or drape folds) that developed due to reactivation of subsurface faults in Precambrian basement rocks that postdates deposition of the Paleozoic rocks. Close association between the base Sinnipee structure contour map and aeromagnetic anomaly map (fig. 5) suggests the structures of the Paleozoic rocks and the Precambrian basement rocks are linked. Aeromagnetic anomalies reflect magnetic minerals in the upper crust (Daniels and Snyder, 2002). In Wisconsin, aeromagnetic anomalies data commonly respond to variations in the Precambrian basement (including buried faults and folds) because the overlying Paleozoic rocks and Quaternary sediments are mostly magnetically transparent. Reactivation of the buried faults post deposition of the Paleozoic cover is supported by the relatively uniform thickness of Sinnipee Group units in the map area, indicating that their deposition was not coincident with deformation.

The Croft and Gregory Branch faults cutting the northeastern limb of the Mineral Point anticline can also be explained with this interpretation. Reactivation of basement faults can generate trishear deformation zones that can brittlely deform overlying rocks through complex fracturing and faulting (Ahmadhadi and others, 2007; Ameen, 1988; Cosgrove, 2015).

The location and orientation of the mapped faults also coincide with the NE-trending boundary of the Lead-Zinc district in the area (fig.2). Furthermore, the Croft Quarry and Croft Quarry cores have enhanced mineralization relative to the rest of the map area, indicating these faults may have influenced fluid flow of mineralized Mississippi Valley- type (MVT) fluids. This link between reactivated Precambrian structures and MVT mineralization has been documented in other areas of southeastern Wisconsin (Haroldson and others, 2018; Luczaj and Huang, 2018).

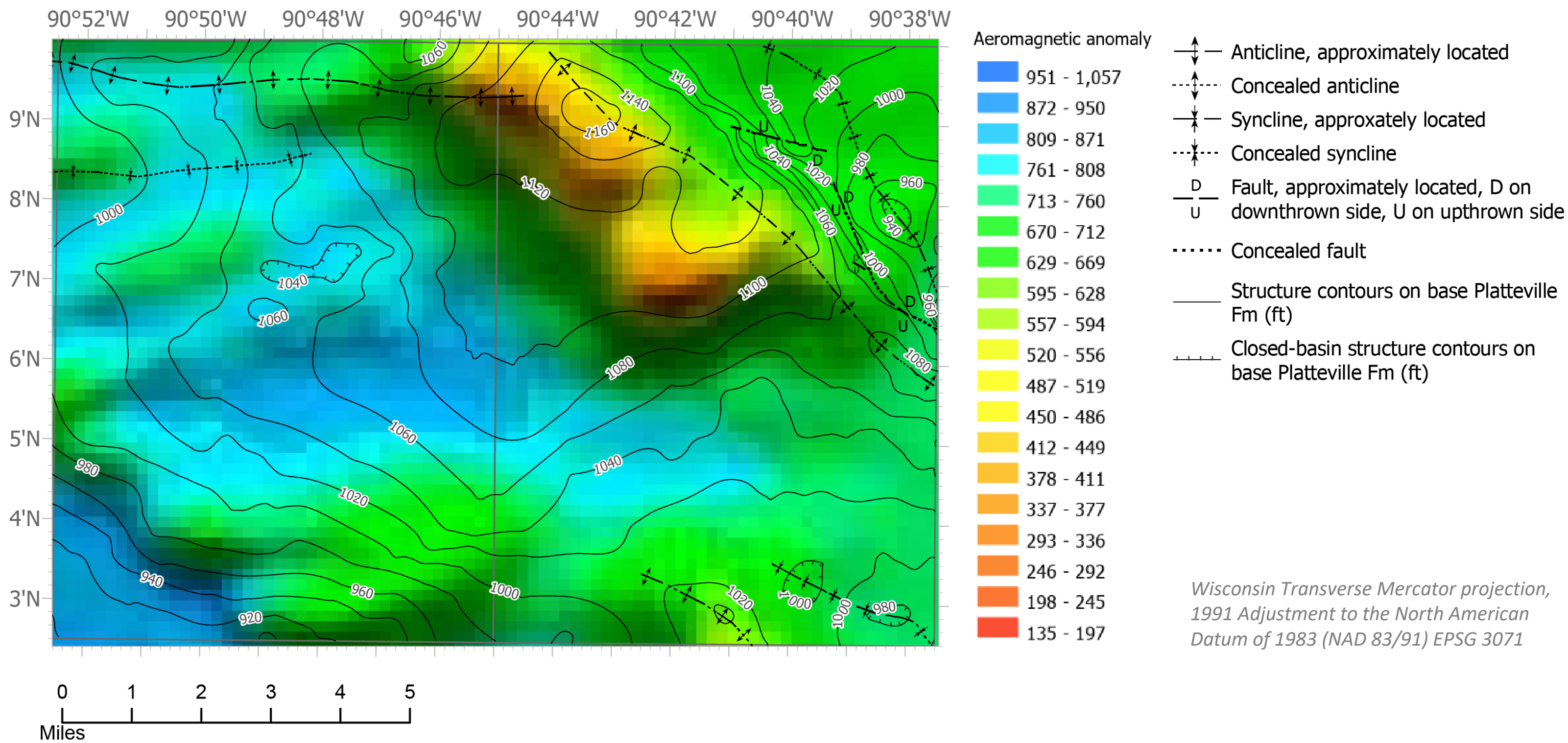

***Figure 5**. Structure contours of the base of the Platteville formation (fig. 1) overlain on aeromagnetic anomaly data (Daniels and Snyder, 2002) in nanoteslas. Aeromagnetic anomalies reflect magnetic contrast in the upper crust; in Wisconsin, this data responds to variations in the Precambrian basement because the overlying Paleozoic rocks and Quaternary sediments are mostly magnetically transparent. Paleozoic fold axes closely align with linear aeromagnetic anomalies, supporting the interpretation that Precambrian structures strongly influence the Paleozoic cover. See Daniels and Snyder (2002) and Stewart and others (2018) for a description of the aeromagnetic dataset.*

Supplemental material

The accompanying materials for this publication are available for download from the WGNHS Publication Catalog at: https://doi.org/10.54915/lmnw3300.

Dataset 1: Geologic log data from the geologic map of the Fennimore and Mt. Hope 7.5-minute quadrangles, Grant County, Wisconsin
Tabulated core descriptions and interpretations (.xlsx format) and high-resolution images (.png format) of core logs.

Dataset 2: GIS data for the geologic map of the Fennimore and Mt. Hope 7.5-minute quadrangles, Grant County, Wisconsin
Includes a geodatabase (.gdb) of unit contacts, field data, geologic logs, mineral development atlas logs, and well construction reports used to construct the base Platteville Formation structure contour raster. Also includes raster dataset of the base Platteville Formation.

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First and foremost, the authors would also like to acknowledge the original inhabitants, caretakers, and protectors of these lands, the Potawatomi and Ho-Chunk Native Nations.

Many thanks to all who contributed to this map, too many to comprehensively list here. Special thanks to all the landowners that allowed access to outcrops on their property, Pete Chase, Billy Fitzpatrick, and Carsyn Ames for coordinating the collection of drill cores and participating in many helpful discussions. Thanks to the student employees who provided field assistance and worked hard to complete core photography.

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Appendix 1

In this appendix we present illustrated lithologic descriptions and map unit divisions for Croft Quarry cores 1–3 (fig. 1, figs. A1.1–A1.3).

A tabulated version of the core descriptions and high-resolution versions of figures A1.1–A1.3 are available for download (dataset 1). The tabulated versions of the core descriptions contain more detail than presented in figures A1.1-A1.3, including porosity, siliciclastic material abundance, bioturbation abundance, and fracture count.

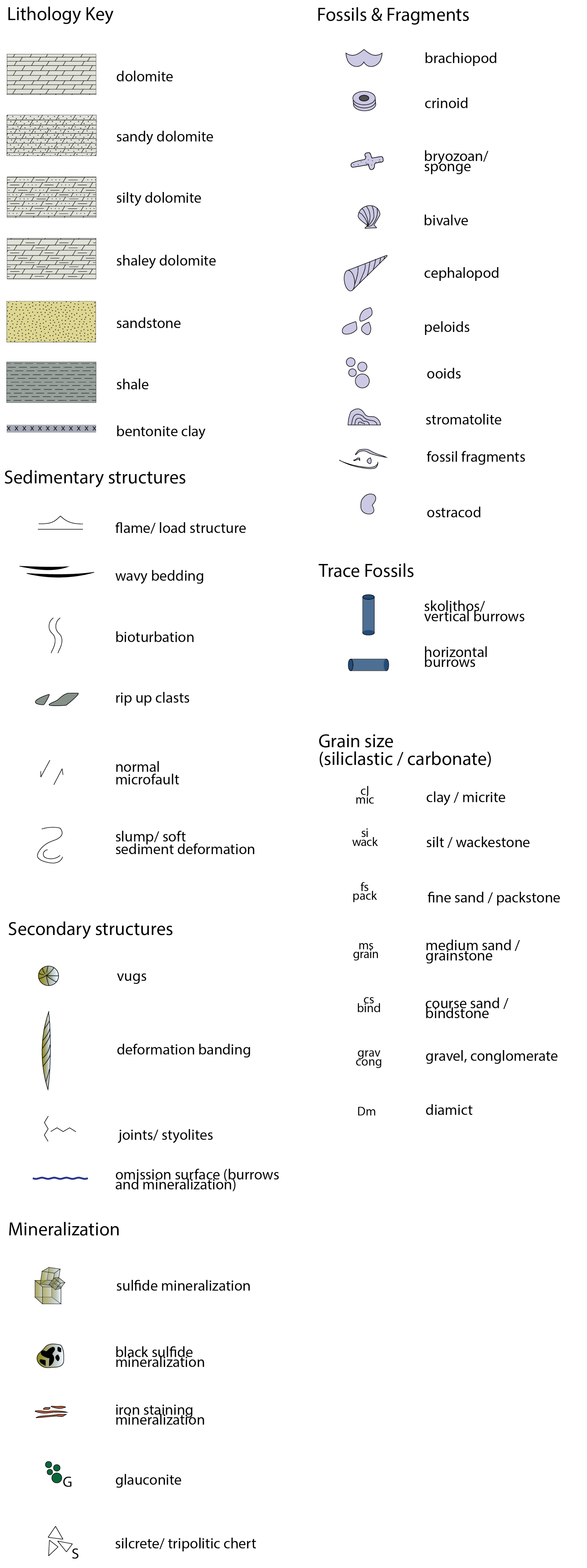

Figure A1.i. *Key for lithologic core descriptions in figures A1.1–A1.3.*

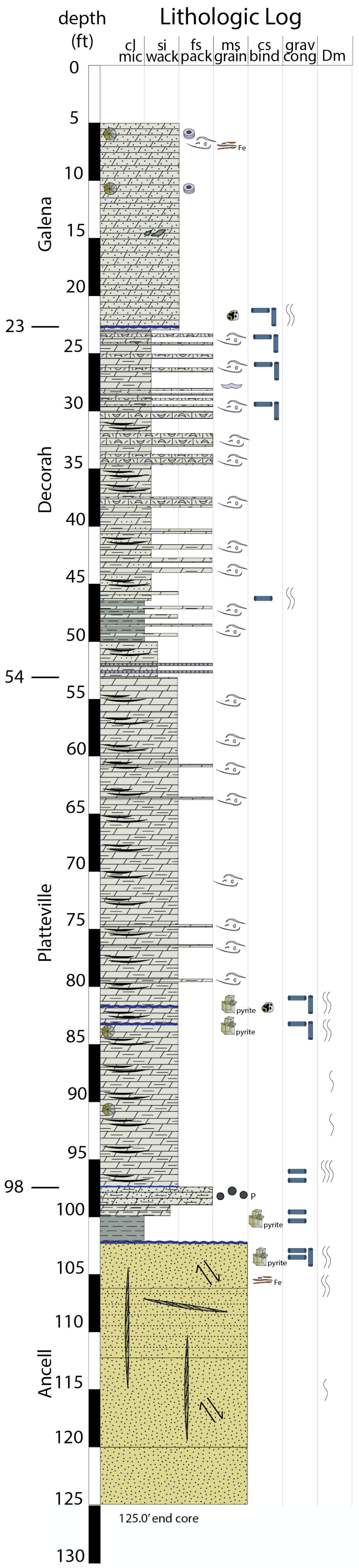

Figure A1.1*. Croft Quarry core 1 lithologic description and map unit divisions for the Galena, Decorah, and Platteville formations of the Sinippee Group and the Ancell Group. All depths are in feet below land surface. A symbology key is presented in figure A1.i. Location of this core is shown in figure 1. For further unit divisions and a more detailed lithologic description, see supplemental dataset 1.*

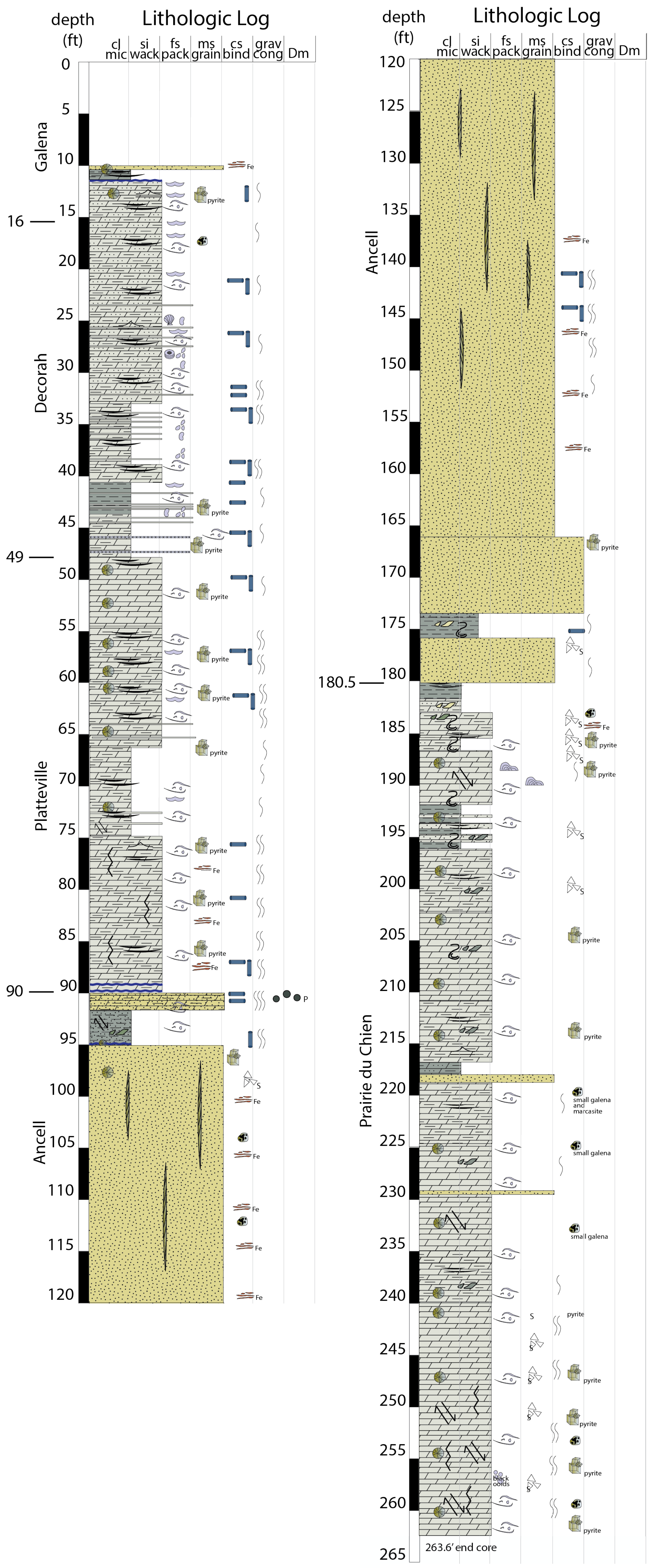

Figure A1.2. *Croft Quarry core 2 lithologic description and map unit divisions for the Galena, Decorah, and Platteville formations of the Sinippee Group ,the Ancell Group, and the Prairie du Chien Group. All depths are in feet below land surface. A symbology key is presented in figure A1.i. Location of this core is shown in figure 1. For further unit divisions and a more detailed lithologic description, see supplemental dataset 1.*

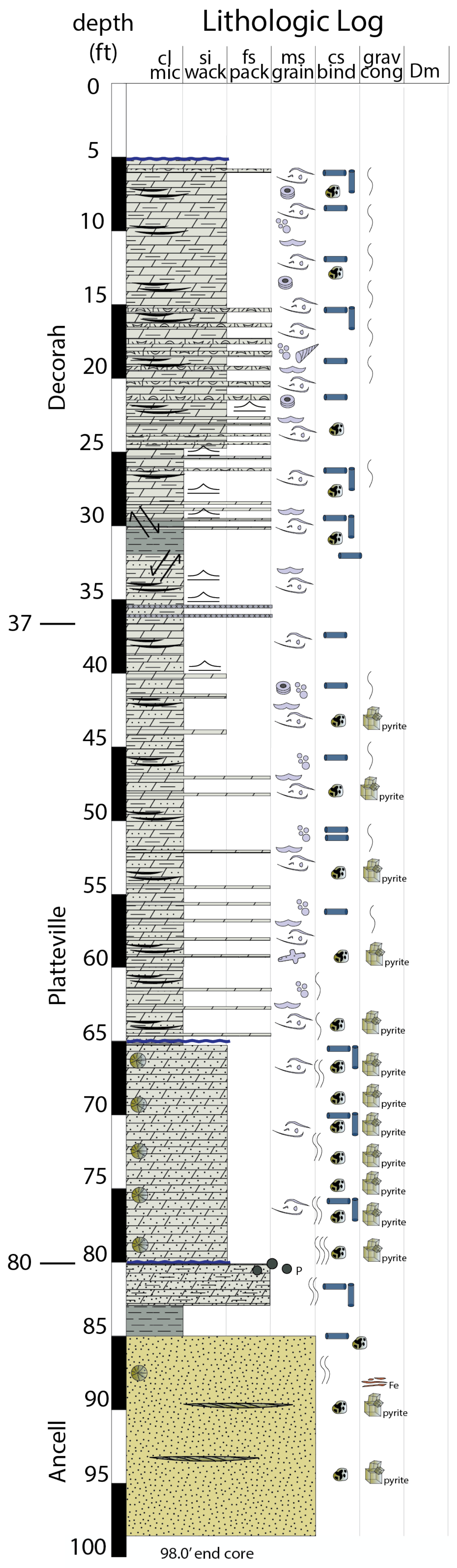

Figure A1.3. *Croft Quarry core 3 lithologic description and map unit divisions for the Decorah and Platteville formations of the Sinippee Group and the Ancell Group. All depths are in feet below land surface. A symbology key is presented in figure A1.i. Location of this core is shown in figure 1. For further unit division and a more detailed lithologic description, see supplemental dataset 1.*