### INTRODUCTION AND SCOPE

The Rock Springs 7.5-minute quadrangle is located in the western Baraboo Hills in south-central Wisconsin. The quadrangle is within the unglaciated Driftless Area of Wisconsin. This map builds on the past work of the authors by continuing to subdivide the Paleoproterozoic Baraboo Quartzite into four mappable members. This approach has yielded a better understanding of Precambrian structural geology and stratigraphy, including the recognition of new faults and basin-scale changes in lithofacies thicknesses that represent progressive changes in depositional environment. The Rock Springs quadrangle is underlain by the Paleoproterozoic Baraboo Quartzite (<1,710 million years old (mega-annum or Ma)), Seeley Slate, and Freedom Formation (Medaris and others, 2003). These rocks were metamorphosed to lower greenschist facies and folded into a series of large, kilometer-scale anticlines and synclines. Smaller-scale folds are superposed on the larger structures. Several episodes of faulting (including a newly recognized extensional event

described here) also displaced Paleoproterozoic map units. During the early Paleozoic, the resistant quartzite formed monadnocks that were eventually buried by sandstone and dolostone during the Sauk and Tippecanoe marine transgressions. Exhumation has re-exposed parts of the lower Paleozoic and Paleoproterozoic sections. During the Quaternary, the Green Bay Lobe of the Laurentide Ice Sheet ended approximately 8 km (kilometers) to the east of the Rock Springs quadrangle. The ice sheet dammed the Baraboo River, producing a proglacial lake consisting of numerous sub-basins, including the West Baraboo, Loganville, and Reedsburg basins in the Rock Springs quadrangle. This map depicts geologic units at the land surface and is meant to convey the rich Precambrian through Quaternary history present on

the ground to both geologists and nongeologists alike. The mapping was heavily focused on the Precambrian section and Paleozoic units were mapped in reconnaissance, which was an approach similar to that of Stewart and Stewart (2020). Paleozoic contacts were mapped on the basis of our own field observations, Lee Clayton's field notes from 1988 on file at the Wisconsin Geological and Natural History Survey (WGNHS), and previous mapping by Wanenamacher (1932), Dalziel and Dott (1970), and Clayton and Attig (1990). Most Quaternary units and contacts were compiled and modified from Clayton and Attig (1990). STRUCTURE

## Precambrian folds

## Baraboo syncline

The Baraboo syncline in the Rock Springs quadrangle plunges gently to the east-northeast. The axial trace of the syncline is buried beneath Paleozoic and Quaternary cover throughout the quadrangle, but historic core logs were used to identify its approximate location (Stewart and others, 2018). The Baraboo syncline in the Rock Springs quadrangle is at the center of a structural depression (cross section A–A') nested within several folds and can be classified as a synclinorium (also see Usbug, 1968).

The Baraboo syncline is an asymmetric fold with a steeply dipping northwestern limb and a shallow-dipping southeastern limb. Just west of the town of North Freedom, Weidman (1904) reported that the Freedom Formation dipped between 45° and 90° on the fold's northwestern fold limb. The fold weakens slightly to the westsouthwest as the interlimb angle decreases from around 110° near North Freedom (cross section A–A') to around 125° near Elder Ridge (cross section B–B'). The axial plane also rotates from steeply northwest dipping near North Freedom to nearly vertical near Elder Ridge.

## Ablemans syncline

Weidman (1904) was the first to correctly interpret the basic structural geometry of the Ablemans syncline, but the fold was not named until mapping by Dalziel and Dott (1970). The Ablemans syncline is a southeast-vergent, asymmetric fold with a nearly vertical northern limb and a shallowly dipping southern limb. The interlimb angle is approximately 80°. The fold is distinct from the Baraboo syncline (cross section A–A'), thus the Ablemans syncline is not a parasitic fold within the greater Baraboo syncline. It probably originated as a fault propagation fold, much like the Baraboo syncline (Stewart and Stewart, 2020) but from displacement along a different buried fault. Small folds

#### The Ablemans syncline and the Baraboo syncline are the two dominant Precambrian folds in the Rock Springs quadrangle (cross section A–A').

Between these two folds are a number of smaller named and unnamed Precambrian folds of which the Diamond Hill anticline is the most significant. The small, unnamed folds depicted in the upper quartzite and metapelite member (Xbqp) in cross section A-A' between the Ablemans syncline and the Diamond Hill anticline are schematically drawn. The mapped contacts and unit thicknesses indicate that there are small undulations present in this area, particularly between the Ablemans anticline and the Ablemans syncline. There, bedding has an average dip of close to 30° SE (as mapped by Dalziel and Dott, 1970), which would require the underlying upper conglomerate and quartzite member (Xbuc) to become exposed within the core of the Ablemans anticline. However, the exposed section remains within the stratigraphically higher upper quartzite and metapelite member (Xbqp). Fluctuating bedding attitudes that support the schematic interpretation in cross section A–A' were found throughout the Diamond Hill area.

## Paleozoic folds

**Borns Hollow syncline** The Borns Hollow syncline is a gently south-southeast-plunging fold in

Cambrian and Ordovician rocks with a total amplitude of around 25 m. This fold has not been previously mapped. Bedding attitudes along the fold axis in the Rock Springs quadrangle and to the south in the Black Hawk quadrangle dip much more steeply than the average dip of the larger structure. Bedding orientations along the axis are inconsistent with a cylindrical fold and may suggest that some of the folding occurred contemporaneous with deposition; during that period, the sediments were soft or unlithified, and they flowed easily. Similar irregularly folded strata along the Denzer syncline to the east in the Sauk Prairie quadrangle likely had a similar origin (Dalziel and Dott, 1970; Clayton and Attig, 1990). Rocks along the fold axis show evidence of both brittle and soft-sediment deformation. Brittle deformation is characterized by throughgoing vertical fractures penetrating through bedsets. Fracture orientations are generally axial planar to the local fold axis. Faults

## North Freedom fault

The North Freedom fault is a northeast-striking, up-on-the-northwest fault buried by Paleozoic sedimentary rocks and glacial lake sediments in the Rock Springs quadrangle. The fault is interpreted to be a reverse fault on the basis of the close association of the buried trace of the fault with the axis of the Baraboo syncline. Such patterns occur when the advancing tip line on a reverse fault migrates through the overlying fault propagation fold. The North Freedom fault was first mapped by Schmidt (1951) and later by Dalziel and Dott (1970), but the buried trace of the fault near the town of North Freedom was modified by Stewart and others (2018).

The fault is not exposed at the surface, but mapping combined with historic drill-core data near Diamond Hill (see Stewart and others, 2018) suggest that the fault places the guartzite and metapelite member (Xbgp) over the lower and middle parts of the Seeley Slate (see cross section A-A' and Dalziel and Dott, 1970). Accurately estimating the amount of slip on the fault is difficult because of the uncertainty in the fault's dip; assuming the fault is a reverse fault with dip-slip motion, the slip was probably around 400 m (see cross sections A–A' and Dalziel and Dott, 1970).

The North Freedom fault is closer to the surface northeast of Elder Ridge in Westfield Township (T11N, R4E, secs. 23 and 24), where it is buried by several tens of meters of the Parfreys Glen Formation. There, the hanging wall of the fault contains meta-conglomerate and quartzite of uncertain affiliation thrust over the quartzite and metapelite member (Xbqp). The conglomerate and quartzite unit in the hanging wall is probably the upper conglomerate and quartzite member (Xbuc), but a lack of exposed section in the area precludes certainty. The lack of control on determining the fault's dip as well as some uncertainty in the hanging wall unit again makes estimating the amount of slip difficult, but a slip between 300 and 350 m is likely using the mapped interpretation. A less favored, alternative interpretation at Elder Ridge is that the fault places the lower conglomerate and quartzite member (Xblc) over the quartzite and metapelite member

## SYMBOLS

	Contact; dashed where approximate
	Normal fault; dashed where approximately located, dotted where concealed. Ball and bar on downthrown side of fault.
🛋	Reverse fault; dotted where concealed. Rectangles on upthrown side.
·	Strike-slip fault; dotted where concealed. Arrows indicate relative sense of movement.
	Anticline; dashed where approximately located, dotted where concealed.
-*	Syncline; dashed where approximately located, dotted where concealed. Large arrowhead shows direction of plunge.
The second secon	Wave-cut scarp (Ordovician)
/ <sup>42</sup>	Inclined bedding—Showing strike and dip
ł	Vertical bedding—Showing strike
80	Overturned bedding—Showing strike and dip
75	Cleavage—Showing strike and dip

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43°28'0'

43°26'0

43°24'0

43°22'3

-90°0'0"

FAUL

Diamond Hil

ANTICLINE

Elde

Ridge

Drill core hole

• Drill core hole with log

#### (Xbqp). This interpretation would increase the amount of displacement along the fault to around 1.5 km. We favor the first interpretation largely

because it is more consistent with slip estimates from the Diamond Hill area. The choice of hanging wall unit along the North Freedom fault at Elder Ridge also affects the interpretation of thickness changes in the members of the Baraboo Quartzite across the Baraboo Hills. Using the favored map interpretation and average bedding dips, the upper conglomerate and quartzite member (Xbuc) has a thickness of at least 600 m in the Elder Ridge area. This thickness suggests that the thickness of the upper conglomerate and quartzite member (Xbuc) increases from 475 m at Abelman's Gorge to over 600 m near Elder Ridge. However, if the hanging wall unit is the lower conglomerate and quartzite member (Xblc), then westward thickening (>350 m) would be required because the lower conglomerate and quartzite member (Xblc) has a thickness of around 250 m to the east near Baxter's Hollow in the North Freedom 7.5-minute quadrangle (Stewart and Stewart, 2020). Narrows Creek fault

The Narrows Creek fault is interpreted as a northwest-striking, leftlateral, strike-slip fault. Dip angle, dip direction, and a possible component of dip-slip motion are unknown. The fault was initially mapped by Kemmer and Kovac (1937), who found bedding rotated counterclockwise on approach to Narrows Creek, which is consistent with a fault with a distributed component of left-lateral displacement. Usbug (1968) disputed the presence of the fault, believing that the quartzite on both sides of Narrows Creek was identical. Dalziel and Dott (1970) favored the interpretation of Kemmer and Kovac (1937).

We verified the presence of the fault by mapping the contact between the upper conglomerate and quartzite member (Xbuc) and the upper quartzite and metapelite member (Xbqp) on the eastern side of Narrows Creek, and we found that this contact shifts across the creek. The sense of displacement based on map patterns must be left-lateral, but the magnitude of displacement is less clear because only conglomeratic quartzite is present on the western side of Narrows Creek. If the rocks on the western side of Narrows Creek are part of the lower conglomerate and quartzite member (Xblc), then left-lateral displacement is larger and is at least 1 km. In our favored interpretation, the rocks on the western side of Narrows Creek are part of the upper conglomerate and quartzite member (Xbuc), and the left-lateral slip is probably close to 200 m.

## Hemlock Draw fault

The Hemlock Draw fault strikes approximately N. 40° E. and is interpreted to be a normal fault with down-to-the-southeast motion. The fault has not been mapped before. The kinematics of the fault were interpreted on the basis of outcrop exposures adjacent to the fault at the headwaters of Hemlock Draw (NW¼ NW¼ sec. 4, T10N, R5E). A series of outcrop-scale listric normal faults with down-to-the-southeast motion is well exposed in heavily fractured quartzite. En echelon quartz veins in outcrop are also consistent with normal, down-to-the-southeast motion. Slickenlines on fracture surfaces suggest dominantly dip-slip motion. Displacement on the fault appears to diminish to the northeast because no evidence for the structure was found in the North Freedom quadrangle to the east. The cross section construction indicates that there has been around 300 m of slip on the fault. The timing of the fault is unknown; however, because it cuts dipping beds in the area, it presumably postdates contractional deformation. It is the only

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SYNCLINE



No vertical exaggeration of cross sections

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# Geologic map of the Rock Springs 7.5-minute quadrangle, Sauk County, Wisconsin

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## **CORRELATION OF MAP UNITS**

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