# Geologic map of the Durwards Glen 7.5-minute quadrangle, Columbia and Sauk counties, Wisconsin

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#### **SYMBOLS**

Contact—dashed where approximate **Baraboo Syncline**—dotted where concealed, dashed where approximate. Arrowhead shows **Moraine crest**—V-symbol points in direction **Drumlin**—arrow shows direction of ice flow **Drumlinized hill**—arrow shows direction of **Inclined bedding**—showing strike and dip **Cleavage**—showing strike and dip **Drill log**—labeled logs appear in cross section

#### INTRODUCTION

The Durwards Glen quadrangle is underlain by the Paleoproterozoic Baraboo Quartzite, Seeley Slate, and Freedom Formation, and by the Mesoproterozoic Dake Quartzite and Rowley Creek Slate (Stewart and others, 2021b). Proterozoic rocks reached lower greenschist facies metamorphic conditions and were folded into the regionally important Baraboo Syncline. During the early Paleozoic, outcrops of the Baraboo Quartzite remained a topographic high. This high was slowly filled in during the Paleozoic Sauk transgression, when Cambrian and Ordovician sandstones and carbonates were deposited on a buttress unconformity with the Baraboo Quartzite.

The Durwards Glen quadrangle also contains a rich glacial history. In the Pleistocene, the Green Bay Lobe of the Laurentide Ice Sheet dammed south and east flowing meltwater and river drainages. This caused glacial Lake Wisconsin to form in what is today known as the Central Sand Plain (Carson and others, 2023). During glacial retreat, catastrophic flooding occurred in the area around Wisconsin Dells when the ice sheet receded past the Baraboo Hills (Bretz, 1950; Clayton and Attig, 1989; Clayton and Knox, 2008). A delta was initially deposited, followed by a glacial lake outflow channel. Windblown sediments were deposited immediately after glacial retreat (Hooyer and others, 2021).

This map includes Precambrian through Quaternary units. New mapping has focused on subdividing the Baraboo Quartzite into four separate members. Paleozoic and Quaternary units were mapped in reconnaissance. Unpublished mapping by Wanenmacher (1932) and Hackbarth (UW-Madison, written commun., 1968), and published mapping by Dalziel and Dott (1970), Clayton and Attig (1990), Carson and others (2020), and Hooyer and others (2021) supplemented field work by the authors.

#### **STRUCTURE**

## **Baraboo Syncline**

The Baraboo syncline is the most significant structure in the Durwards Glen quadrangle. The fold trends approximately 260. Bedding in the northern limb of the fold dips subvertical, and bedding in the south limb decreases from around 60° NW in the east to around 30° NW at the western edge of the quadrangle. Quartz grains near the hinge are heavily recrystallized, and primary sedimentary structures are difficult to observe in most areas.

The plunge on the fold axis is variable and is interpreted to fluctuate. Core logs through the Freedom Formation and Seely Slate in the interior of the syncline (Stewart and others, 2018) require a plunge that varies from approximately 35° WSW to nearly horizontal (see cross section A along the axis of the syncline). Outcrops of Baraboo Quartzite at the surface also suggest a plunge of around 35° WSW, but reasonable thickness estimates for the upper quartzite and metapelite member suggest the plunge flattens between areas of exposure at the surface and areas of core control to the west. The cause of the fluctuating plunge is unclear, but its presence indicates the Baraboo syncline is more complicated than a simple doubly plunging fold.

## **STRATIGRAPHY**

# Freedom Formation - Dake Quartzite Unconformity

The Baraboo Quartzite was deposited in fluvial, eolian, and tide-influenced deltaic environments with sediments sourced from the north. It is gradational, and presumably conformable, with the overlying Seeley Slate and Freedom Formation. The contact between the Freedom Formation and Dake Quartzite is interpreted to be an angular unconformity, and sediment provenance for the Dake Quartzite was both to the north and south (Stewart and others, 2021b). However, in the Durwards Glen quadrangle, the Dake Quartzite was deposited on the lower ferruginous member of the Freedom Formation, and the dip of the Dake Quartzite appears to be slightly less than underlying units (cross section B). Additionally, while the Dake Quartzite is folded (cross section B), the hinge does not have a noticeable plunge (cross section A). This causes the underlying Freedom Formation to taper and thin progressively eastward. These map relations indicate the Dake Quartzite was deposited after an initial pulse of deformation but before the main event that produced the Baraboo syncline. It is unclear if these two pulses of deformation were part of the same orogenic event or represent two separate events.

## **MINERALIZATION**

A suite of secondary minerals are widely present within the Baraboo quartzite of the Durwards Glen Quadrangles as veins, fracture coatings and as thin seams along cleavages. Quartz veins are present sporadically as conjugate sets with dominant NW-SE and NE-SW orientations, generally steeply dipping but with some moderate dips. Veins are typically 1 mm – 3 cm thick but can range up to 5-6 cm thick and commonly form <1-3% of the total outcrop area where present. This increases over restricted lateral distances, with swarms of veins comprising 10–20% over 1–2 m. Individual veins are commonly lens-shaped, able to be traced for only 10–50 cm along strike before pinching out. Quartz veins sometimes show evidence of deformation, forming sigmoidal geometries or showing slight curvature in fine banding within quartz fill perpendicular or oblique to the vein walls. In most cases fill within veins is exclusively white to transparent quartz, but well-crystallized plates of gray specular hematite commonly form 1–5% of veins as < 1 mm – 1 cm patches within vein quartz. The Baraboo Quartzite elsewhere in the Baraboo Hills contains areas where quartz vein swarms grade into larger areas of quartz breccia such as at Rock Springs (Dalziel and Dott, 1970; Greenberg, 1986) but none are known within the Durwards Glen quadrangle.

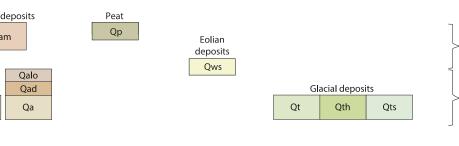
Fracture and cleavage coatings of white, very fine-grained, soapy kaolinite are abundant within the Baraboo Quartzite. A gradation is present from patches of kaolinite on fracture surfaces, to fracture coatings, with the thickest examples approaching 5 mm thickness forming thin veins. Kaolinite coated fractures commonly accompany quartz veins in outcrop, sometimes forming a thin centerline fill in quartz veins.

Red, fine-grained hematite is another common cleavage coating in the Baraboo Quartzite. Occasionally red hematite cleavages also contain minor yellow-green epidote. At one location red fine-grained hematite and epidote were seen together with quartz filling veins.

One quartzite ridge in the NW 1/4 Sec. 4, T11N R8E was investigated in a detailed ~750 m traverse recording the presence and abundance of the various hydrothermal minerals through a zone of semi-continuous exposure perpendicular to bedding. Bedding on the ridge dips approximately 45° to the NNW exposing a total vertical section of roughly 500 m for observation. Through this traverse there was a change from hematite + epidote cleavage and fracture coatings in the deepest (southernmost) portion grading to kaolinite fracture and cleavage fill, to quartz + specular hematite veins in the shallowest portion. All three mineral assemblages have gradational boundaries with one another and are present together through transitional zones.

# -89°37'30" SCALE 1:24 000 1 0.5 0 1 0.5 0 Wisconsin Transverse Mercator Projection, 1991 adjustment to the Mapped and compiled by North American Datum of 1983 (NAD 83/91); EPSG 3071 Eric D. Stewart, Esther K. Stewart, and William A. Fitzpatrick, 2015-2022 Contour interval is 20 feet Map base from U.S. Geological Survey, The National Map digital data US TOPO map series, Geodatabase and cartography by Nick Rompa 2016 and 2017; U.S. Census Bureau TIGER/Line data, 2015; and Wisconsin Department of GIS data that accompany this map can be found at: Natural Resources, 2016; modified by the Wisconsin Geological and Natural History Survey. https://doi.org/10.54915/tbkd9460 The map and cross sections are interpretations of the data available at the time of preparation. Every reasonable effort has been made to ensure that this This geologic map was funded in part by the U.S. Geological Survey interpretation conforms to sound scientific and cartographic principles; however, National Cooperative Geologic Mapping Program under STATEMAP the map should not be used to guide site-specific decisions without verification. award number G22AC00311, 2022 Proper use of the map is the sole responsibility of the user. No vertical exaggeration A'-A" section SOUTH RANGE

#### **CORRELATION OF MAP UNITS**



## **MAP UNITS**

### **QUATERNARY**

Organic-rich sediment Organic-rich, partially decomposed plant material. Found in wet, flat-lying areas. Hoover and set a factor flat-lying areas. Hooyer and others (2021) estimated typical peat thicknesses of 1 to 5 m in Columbia County.

**Qam** Modern fine-grained sand, silt, and clay stream sediment. Larger cobbles and boulders are also present along the flanks of the Baraboo Range. Often formed from reworked Pleistocene glacial sediment. Qalo Pleistocene glacial lake outlet stream sediment deposited in a channel that incised into Qad (described below). Qad Gravel, cobbles, and sand, with boulders reaching 1.5 m. Deposited in foresets reaching 12 m high (Bretz, 1950). Deposited during the initial stages of the draining of glacial Lake Wisconsin at the Alloa outlet (Clayton and Attig, 1989).

#### Meltwater-stream sediment

**Qa** Late Pleistocene gravel and sand deposited by meltwater streams in the Wisconsin River valley, deposited distal from the ice margin. **Qsc** Gravel and sand deposited as meltwater stream sediment. Scattered glacial sediment within Qsc becomes more abundant eastward. The unit is generally located adjacent to prominent moraines and is found only in the southwestern portion of the quadrangle. In Sauk County, this unit was previously mapped as collapsed meltwater stream sediment (Clayton and Attig, 1990). In Columbia County, this unit was previously mapped as till of the Holy Hill Formation (Hooyer and others, 2021).

### Windblown sediment

Well sorted windblown sand deposited in sheets and 3D dunes with approximately 2.5 m of relief.

Composed of poorly sorted boulder, cobble, sand, silt, and clay deposited by the Green Bay Lobe of the Laurentide Ice Sheet near the end of the Pleistocene (Carson and others, 2020). Part of the Horicon member of the Holy Hill Formation (Syverson and underlying bedrock. The unit contains numerous bedrockcored and sediment-cored drumlins. Qth Hummocky topography with kettle lakes and ponds common. Qts Largely lake sediment deposited as part of the East Baraboo Basin of Glacial Lake Wisconsin (Clayton and Attig, 1990). The unit is only found adjacent to Rowley Creek at the western edge of the map area. May contain some till.

## **ORDOVICIAN**

St. Peter Formation White, tan, and orange, dominantly fine- to medium-grained sandstone with minor coarse sand grains. Moderately poor sorting. The St. Peter Formation is well exposed at Pine Bluff in the interior of the Baraboo Ranges. Quartz overgrowths are well developed at the top of the bluff, forming a resistant cap. Deformation bands are also abundant in the upper 3 m of exposure at Pine Bluff. Cm-scale, purple goethitic clusters and bands after iron sulfide are common, often at the boundaries of deformation band swarms. Approximately 50 m of section is

#### Prairie du Chien Group Opc Light-gray, coarse-grained crystalline dolomite to sandy

exposed at Pine Bluff.

St. Peter Formation.

## ORDOVICIAN TO CAMBRIAN

## Parfreys Glen Formation

O€pg Pink to tan conglomerate and fine- to medium-grained quartz sandstone. Baraboo Quartzite boulders, cobbles and pebbles are the primary clasts in conglomeratic beds. Glauconite and burrows are present in some sandstone beds. The Parfreys Glen Formation drapes Cambrian to Ordovician topographic highs. Its thickness is variable, and it laterally grades into typical Cambrian to Ordovician stratigraphic units.

dolomite. Chert is common. Bedding varies from laminated, to

thin-bedded, to massive. Vugs are common. Stromatolites were

observed in the interior of the Baraboo Ranges. The thickness of

the unit is variable due to the unconformable contact with the

#### Ordovician to Cambrian undivided sedimentary rocks O€u Cross section only. Undivided Ordovician to Cambrian dolomite, shale, and sandstone.

# **CAMBRIAN**

# **Jordan Formation**

Whalen

Tan to light brown, fine- to coarse-grained quartz arenite. The upper Jordan sometimes contains a dolomite cement (Wanenmacher, 1932). Grains are generally well-rounded and well to moderately sorted. Crossbedding is common. Clay laminations and Skolithos trace fossils occur locally (Wanenmacher, 1932). The unit is approximately 20 m thick.

# St. Lawrence Formation

White to tan, fine-grained carbonate cemented sandstone. The St. Lawrence Formation is poorly exposed largely due to burial by glacial sediment. Southeast of the Durwards Glen quadrangle near Lodi, the St. Lawrence transitions into a purple to tan carbonate-cemented siltstone and gray dolomite. The unit is approximately 20 m thick.

# Tunnel City Formation

the Baraboo Ranges, quartzite pebbles are common. The Tunnel City Formation contains carbonate-cemented sandstone, sometimes with trace glauconite, interbedded with clean quartz sandstone. Some beds also contain hematite cement. Crossbedding is common. Bedsets are typically tens of cm-thick. Crinoids were observed at the west end of Petra Road. The unit is

approximately 30 to 45 m thick.

of the section has been eroded away.

# Elk Mound Group

Tan to white, fine- to coarse-grained quartz arenite. The unit is poorly exposed. Most exposures are probably part of the Wonewac Formation. Elsewhere in the Baraboo Ranges, quartz grains in the upper Elk Mound Group are typically moderately to well sorted, and well rounded (Stewart and others, 2021a). The Elk Mound Group is absent from higher elevation portions of the Baraboo Ranges, but full thicknesses can be greater than 100 m in the interior. Outside of the Baraboo Ranges, the thickness of the Elk Mound Group increases rapidly. Original thicknesses of around 150 m are inferred near the town of Merrimac, but part

# **MESOPROTEROZOIC**

# Dake Ouartzite and Rowley Creek Slate

Combined, cross section only. The Dake Quartzite is a white, fine-grained quartzite to red-brown pebble (meta) conglomerate. Red-brown, iron-rich conglomerate is focused near the base of the unit, which lies unconformably over the ferruginous member of the Freedom Formation. Geiger (1986) reported kaolinite-rich clasts in core that were interpreted to represent weathered detrital feldspars. Outcrop exposure of the Dake Quartzite, however, shows no evidence of detrital feldspar. The thickness of the Dake Quartzite is estimated to be 65 m based on drill core.

The Rowley Creek Slate is a tan slate that overlies the Dake Quartzite. Drill core indicates a minimum thickness of 45 m.

# **PALEOPROTEROZOIC**

# Freedom Formation

Cross section only. The Freedom Formation contains a lower ferruginous member and an upper dolomitic member. The ferruginous member contains interbedded iron-rich slate, chert, and minor dolomite. The upper member contains primarily dolomite with minor slate, but the upper member has probably been eroded away in the Durwards Glen quadrangle. The total thickness of the Freedom Formation is probably greater than 300 m, but most of that thickness has been eroded away.

Cross section only. Gray to black slate with minor fine-grained quartzite near the top of the unit (Stewart and others, 2021a). The Seeley Slate is around 90 m thick in the Durwards Glen quadrangle.

# > PROTEROZOIC Intrusive rocks

#### Baraboo Quartzite

Upper quartzite and metapelite member

Pink to purple, fine- to medium-grained quartzite. The member is poorly exposed in the Durwards Glen quadrangle. Elsewhere in the Baraboo Ranges, it typically contains interbedded black to gray metapelite and sandy metapelite that varies from 10 cm to 6 m in thickness. Metapelite typically becomes progressively more abundant stratigraphically higher in the unit. Quartzite is composed of clean quartz sand. Trough crossbedding is common in the unit elsewhere, but the quartzite is heavily recrystallized in the map area and bedding is difficult to observe. Stewart and others (2021b) interpreted a wave and tide influenced medial to distal delta front depositional environment for the member. The full thickness of the unit is not exposed, but cross sections suggest a thickness of around 275 to 335 m.

## Upper conglomerate and quartzite member

Pink to purple, fine- to medium-grained quartzite with granule and pebble heds 1 to 2 cm third. and pebble beds 1 to 3 cm thick. Elsewhere in the Baraboo Ranges, pebble beds reach up to 20 cm thick. Pebbles are composed of vein quartz, polycrystalline quartz, and red jasper. Quartzite is composed of clean quartz sand. The member is heavily recrystallized in the Durwards Glen quadrangle, and sedimentary structures are difficult to observe. Stewart and others (2021b) interpreted a fluvial, wave, and tide influenced proximal to distal delta front depositional environment for the member. The thickness is poorly constrained and may have been tectonically thinned. Thicknesses estimated from cross section range from 475 m to 610 m.

#### Lower quartzite member

Xblq Pink to purple, fine- to medium-grained quartzite. Isolated pebbles and one-pebble-thick lags occur sporadically across the unit. Phyllitic beds, less than 3 cm thick, were observed rarely. Composed of clean quartz sand. Quartz grains are strongly recrystallized in the Durwards Glen quadrangle, and primary sedimentary structures are difficult to observe. Stewart and others (2021b) interpreted an aeolian, ephemeral stream, and ephemeral pond environment for the lower quartzite member based on exposures in the North Freedom quadrangle. The estimated thickness of the member based on cross sections is in the range of 460 m to 580 m.

## Lower conglomerate member

Pink to purple pebble conglomerate to coarse- to fine-grained quartzite. This member was mapped where conglomerate beds exceed 1 cm in thickness. Framework grains in quartzite beds are composed of pure quartz sand. Conglomerate bed sets are often lenticular in shape. Stewart and others (2021b) interpreted a fluvial braid plain to delta front depositional environment for the lower conglomerate member. The thickness of the member is interpreted to vary significantly. It is less than 80 m thick at Caledonia Church where rhyolite is exposed, but may be as much as 600 m thick based on isolated outcrops 3.5 km to the southwest. Interfingering of the conglomeratic fluvial facies of the lower conglomerate member with the finer-grained, fluvial to aeolian lower quartzite member is likely responsible for the thickness changes, but poor exposure due to glacial cover makes assessment of the dominant sedimentary facies unclear. An overestimate of the thickness of the lower conglomerate member is possible, though relatively rapid thickness changes in the lower conglomerate member are suggested elsewhere in

the South Range (Stewart and others, 2021a, Stewart and

Stewart, 2021).

Gray to red, flow banded rhyolite. Exposures at Caledonia Church contain angular clasts of plagioclase feldspar and banded rhyolite set within a flow banded matrix. Stark (1932) interpreted the rhyolite as a flow breccia.

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Title VI, Title IX, the Americans with Disabilities Act (ADA), and Section 504

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