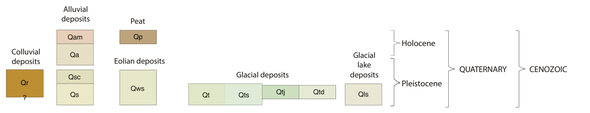
Geologic map of the Baraboo 7.5-minute quadrangle, Sauk County, Wisconsin

Esther K. Stewart and Eric D. Stewart

CORRELATION OF MAP UNITS



MAP UNITS

QUATERNARY

Peat

Qp — Present within wetlands as late Holocene deposits up to several meters thick. Overlies adjacent map units (Clayton and Attig, 1990).

Alluvium

Qam, Qa — **Qam** Modern fine-grained sand, silt, and mud overbank stream deposits. The unit is marked by incision into pre-existing glacial and lacustrine sediments. Along parts of the Baraboo River, Qam is less than 2 m thick and is underlain by lake sediment (Eric Carson, WGNHS, 2020, written communication). **Qa** Pre-modern fine-grained sand and silt. Occurs as fans of hillslope sediment along south-facing slopes in the southwestern portion of the map area. Holocene to latest Pleistocene.

Meltwater-stream sediment

Qs, Qsc — **Qs** Gravel and sand deposited as stream sediment on an outwash plain adjacent to the Johnstown moraine. Gravel is common near the contact with the Johnstown moraine and fines to sand to the west (Clayton and Attig, 1990). **Qsc** Similar to Qs but with hummocky topography because of deposition on stagnant ice. Locally, thin till may drape older sand deposits and till may project through a thin surface layer of sand (Clayton and Attig, 1990).

Lake sediment

Qls — Sand and lesser silt and clay deposited as offshore lake sediment. Lake sediment was deposited in the eastern Baraboo basin, an arm of the larger glacial Lake Wisconsin (Clayton and Attig, 1990). Throughout much of the area, lake sediment is probably present beneath a thin (less than 2 m thick) veneer of alluvium (Qam) (Eric Carson, WGNHS, 2020, personal communication).

Glacial sediment

Qt, Qts, Qtj, Qtd — **Qt** Glacial till composed of poorly sorted, clay, silt, sand, and gravel with less abundant cobbles and boulders. Gravel is commonly rich in dolomite clasts (Clayton and Attig, 1990). Boulders are often composed of Baraboo Quartzite or Precambrian intrusive rocks derived from the Wisconsin Dome. The till was deposited by the Green Bay Lobe of the Laurentide Ice Sheet. **Qts** Similar to Qt but includes areas of offshore lake sediment similar to Qls. **Qtj** Till of the Johnstown moraine composed of a basal boulder gravel overlain by layered sandy till and capped by a thin layer of boulder gravel (Lundqvist and others, 1993). **Qtd** Thin till (meters to tens of meters thick) overlying pre-existing outwash deposits (Clayton and Attig, 1990).

Windblown silt

Qws — Windblown silt (at least 1.5 m thick) overlying outwash stream sediment. Deposited during the latter stages of the most recent glaciation (Clayton and Attig, 1990).

Rock glacier

Qr — Linear talus piles composed of quartzite boulders several meters to tens of meters thick; typically originates below ledge-forming quartzite outcrops and trends downslope; exhibits locally preserved ridges suggestive of flow banding.

ORDOVICIAN TO CAMBRIAN

Parfreys Glen Formation

OCpg — Pink to tan conglomerate and tan to brown, fine- to medium-grained quartz arenite. Conglomerate beds contain clasts of Baraboo Quartzite in a clean sandstone or glauconitic sandstone matrix. Conglomerate clasts typically are present as a continuous range of sizes from pebbles to cobbles; some can be up to several meters in diameter. Conglomerate is present in medium- to massively bedded tabular sets, as well as at the base of upward-fining, decimeter- to meter-thick, lenticular beds capped with sandstone. Quartz arenite intervals are present as both medium- to massively bedded tabular sets as well as the caps of decimeter- to meter-scale lenticular beds. Planar and trough crossbedding is common in sandstone bedsets. Pebbles of Baraboo Quartzite are present draping crossbedded foresets or floating within sandstone beds. The thickness of the unit is unclear because it drapes underlying Precambrian basement topography. The unit is equivalent to the Cambrian Elk Mound Group through at least the Ordovician Oneota Formation.

CAMBRIAN

Jordan Formation

Cj — Generally tan to gray to white, fine- to coarse-grained, well-rounded, well- to moderately sorted quartz arenite. Trough crossbeds and low-angle crossbeds are common within medium- to thin-bedded, tabular bedsets. The unit tends to form cliffs (Clayton and Attig, 1990), although this morphology is muted in the Baraboo quadrangle because of glacial modification of the bedrock. Approximately 20 m thick. Upper formation of Trempealeau Group.

St. Lawrence Formation

Csl — Tan, very fine to fine-grained, carbonate-cemented sandstone. The unit is very poorly exposed in the Baraboo quadrangle but tends to form flat benches above the Tunnel City Group and below the cliff-forming Jordan Formation (Clayton and Attig, 1990); however, this morphology is muted because of glacial modification of the bedrock. Approximately 12 m thick. Lower formation of Trempealeau Group.

Tunnel City Group, undivided

Ctc — Tan to brown, generally fine-grained sandstone with lesser medium-grained sandstone. Typically well to moderately rounded and moderately sorted. Carbonate-cemented sandstone with common trace glauconite grains is interbedded with clean quartz arenite in tabular bedsets tens of centimeters thick. This unit is locally cemented with hematite. Minor detrital feldspar has been reported (Clayton and Attig, 1990). Crossbedding is common throughout. Regionally, unit outcrops are sparse and are characterized by low-gradient, gently undulating slopes (Clayton and Attig, 1990). In the Baraboo quadrangle, this unit is present as a subcrop beneath glacial till in the northern part of the quadrangle with limited to no exposure. Approximately 30 m thick.

Wonewoc Formation

Cw — Tan to white, fine- to coarse-grained quartz arenite. Sand grains are generally well rounded and moderately to well sorted. Bedsets range from tens of centimeters to over a meter in thickness and are planar tabular or lenticular. Crossbedding is common. The Wonewoc Formation generally is coarser grained than the overlying Tunnel City Group and tends to form steep cliff faces. The base of the unit is not exposed in the Baraboo quadrangle, but in the Baraboo Hills region its thickness is around 30 m (Dalziel and Dott, 1970). Topmost formation of Elk Mound Group.

Elk Mound Group, undivided

Cu — Cross section only. Sandstone.

MESOPROTEROZOIC(?) TO PALEOPROTEROZOIC

Rowley Creek Slate

Cross section only. Reported to be a gray slate composed dominantly of sericite, quartz, and chlorite (Leith, 1935). At least 45 m thick.

Dake Quartzite

Gray to purple, fine- to coarse-grained, moderately to poorly sorted quartzite and pebble conglomerate. To the west, this unit includes lesser fine-grained, well-sorted quartzite and metapelite interbeds. Clasts range in size up to 2 centimeters (cm) and are mostly quartz with less abundant jasper and slate. Quartz is the dominant matrix constituent in conglomeratic intervals. Quartzite beds range from 5 to 50 cm thick and are organized into both lenticular and broadly tabular bedsets that are separated by thin (1 millimeter to 5 cm thick) metapelite or sandy metapelite interbeds. Sedimentary structures include trough crossbeds and angular, centimeter-scale, red-mud-chip rip-up clasts that tend to be locally concentrated along bedding surfaces. Approximately 45 m thick; thickens to approximately 65 m to the west. Overlies the Freedom Formation across an angular unconformity. Detrital zircons from the Dake Quartzite give a maximum depositional age of 1,630.1±8.6 Ma (Stewart and others, 2021), suggesting either a Mesoproterozoic or latest Paleoproterozoic age.

Freedom Formation

Xf — Cross section only. Composed of a lower gray to white to red, iron-rich member and an upper white to gray, dolomite-rich member. The lower member is an iron formation composed of interlaminated chert, silicate minerals, iron-oxide minerals (including magnetite and hematite), and lesser interbedded dolomite. Weidman (1904) reports mudcracks in the lower member at the Illinois mine. The upper member is composed primarily of dolomite, often massively bedded. The top of the formation is cut by an angular unconformity that locally removes the upper member and separates the unit from the overlying Dake Quartzite. The Freedom Formation is estimated to be at least 480 m thick near North Freedom (Stewart and others, 2018). In the Baraboo quadrangle, the unit is also estimated to be about 480 m thick beneath the locally named Dake Ridge and thins to 169 m to the south across a lateral distance of 1.3 km due to incision by the overlying Dake Quartzite. Overlies the Seeley Slate across a gradational, conformable contact.

Seeley Slate

Xs — Cross section only. Soft, gray to black slate that grades up into a slate with lesser siltstone and very fine-grained sandstone interlaminations. Bedding is thick to massive at the base of the unit and grades to thin and laminated near the top. Sedimentary structures—including ripples, scours, and graded beds—are common at the top of the unit. Dalziel and Dott (1970) estimated a thickness of 110 m, whereas Weidman (1904) estimated a thickness of 150–300 m. Overlies the Baraboo Quartzite across a conformable contact.

Baraboo Quartzite

Upper quartzite and metapelite member

Xbqp — Pink to purple, dominantly fine- to medium-grained quartzite with subordinate interbedded dark-gray metapelite and sandy metapelite. Quartzite is composed of clean quartz sand and local, isolated quartz pebbles and is organized into tabular and broadly lenticular beds tens of centimeters to 1 m thick. Crossbedding is common and predominantly planar-tabular. Thin (approximately 20 cm), tabular, fine-grained quartzite bedsets are locally planar laminated. Metapelite beds are commonly 10–20 cm thick and may reach several meters in thickness (for example, Marshak and others, 2016). Chevron folds are common locally in metapelite horizons. Estimated thickness of 300 m in the Baraboo quadrangle. Overlies the upper conglomerate and quartzite member across a gradational contact.

Upper conglomerate and quartzite member

Xbuc — Pink to purple, fine- to medium-grained quartzite with local pebble beds up to 20 cm thick and uncommon, thin metapelite beds up to approximately 10 cm thick. Quartzite is composed of compositionally mature quartz sand. Pebbles in conglomerate beds are composed of well-rounded monocrystalline quartz and polycrystalline quartz; and lesser, subrounded to subangular jasper, red rhyolite, and gray slate or chert. Pebbles are typically up to 1 cm in length. The base of the member is characterized by a marked increase in approximately 3-cm-thick pebble beds. The overall abundance of pebble conglomerate is minor, and conglomerate abundance is less than what is present in the lower conglomerate and quartzite member (Xblc). Distinctive, high-angle planar-tabular bedsets generally several centimeters to tens of centimeters thick and truncated by reactivation surfaces are common and diagnostic of this unit. Pebble conglomerate beds commonly overlie reactivation surfaces. A broad channel form some 6 m across was observed at the top of this unit. This unit is equivalent to the upper member of Henry (1975) and is estimated to thicken from approximately 975 m in the North Freedom quadrangle (Stewart and Stewart, 2020) to 1,205 m in the Baraboo quadrangle. Interpretation of internal bedding are shown by dashed lines within the unit in cross section. Overlies the lower quartzite member across a gradational contact.

Lower quartzite member

Xblq — Generally pink to purple, fine- to medium-grained, compositionally mature quartzite. Pebble lags one pebble thick are rarely present throughout the unit. Overall, the unit is significantly finer grained than the underlying conglomerate unit. Isolated pebble clasts reaching 2 cm in diameter are present in the upper half of the member and are not associated with continuous conglomeratic beds. Common, thin (centimeter scale) sets of crossbedded strata are locally organized into wedge-shaped cosets tens of centimeters thick. Medium (10–30 cm thick) tangential crossbeds characterized by reverse grading are bounded by high-angle scour surfaces draped by metasiltstone laminations. Laterally discontinuous phyllitic beds and laminations at least 1.5 m thick are present near the base of the member and are deformed into chevron folds (see supplemental field trip stop H in Dalziel and Dott, 1970). This unit is equivalent to the middle member of Henry (1975). This unit has an estimated thickness of 520 m in the South Range in the North Freedom quadrangle and 310 m in the Baraboo quadrangle. Overlies the lower conglomerate and quartzite member across a gradational to sharp contact.

Lower conglomerate and quartzite member

Xblc — Pink to purple pebble conglomerate to fine-grained quartzite. Fine- to coarse-grained quartzite beds are composed of nearly pure quartz sand. The composition of pebbles in conglomerate beds is dominated by well-rounded monocrystalline and polycrystalline quartz; includes subordinate red, subrounded to subangular jasper and rhyolite; and gray, angular slate or chert. Conglomerate beds are clast supported with a matrix composed of quartz sand. Individual pebbles in conglomerate beds are generally up to 1 cm long. Pebble beds are most abundant near the base of the unit, where beds commonly reach 20 cm in thickness. Pebbles become less prevalent upsection. The top of the unit contains sporadic 3-cm-thick pebble beds; locally rounded 3-cm-long quartz pebbles are observed associated with pebble lags composed of approximately 3–5 mm-diameter quartz pebbles and overlying scour surfaces. Crossbedding is common in both quartzite and conglomerate beds and is locally organized into wedge-shaped bedsets tens of centimeters thick. Rare, localized channel forms about 5 m across are also present. This unit is equivalent to the lower member of Henry (1975). Its thickness varies across the Baraboo Hills, but is estimated to be approximately 250 m near Baxters Hollow in the North Freedom quadrangle and thins to the east, with an approximate thickness of 75 m in the Baraboo quadrangle. This member and overlying units were deposited after 1,710 Ma on the basis of U-Pb ages of detrital zircons sampled from near the basal contact (Medaris and others, 2003).

Rhyolite and granite

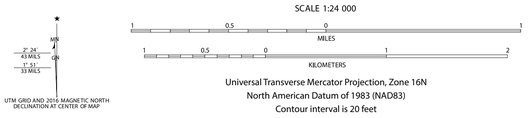
Xrg — Dark-red rhyolite exposed at the base of the southern face of Devils Nose and at the base of the northern face of the North Range near the Lower Narrows. Where this unit outcrops in the Baraboo quadrangle, it is a crystal tuff with a devitrified matrix; altered, medium-grained plagioclase phenocrysts; and fiame. The outcrop at Devils Nose is characterized by a pronounced, ropey texture interpreted as flow banding. Flow banding at the Lower Narrows is expressed as faint laminations on a glassy surface. The rhyolite at the Lower Narrows is 1,746±11 Ma (Van Wyck, 1995).

ACKNOWLEDGMENTS

The authors appreciate the numerous landowners who provided land access during the course of mapping. The authors also appreciate The Nature Conservancy for help with land access. Discussions and field assistance by John Attig were particularly appreciated.

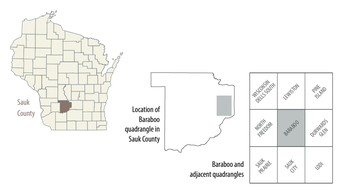
Mapped and compiled by
Eric D. Stewart and Esther K. Stewart, 2016–2017
Geodatabase and cartography by K.C. Roushar

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 interpretation conforms to sound scientific and cartographic principles; however, the map should not be used to guide site-specific decisions without verification. Proper use of the map is the sole responsibility of the user.



Universal Transverse Mercator Projection, Zone 16N
North American Datum of 1983 (NAD83)
Contour interval is 20 feet

Map base from U.S. Geological Survey, The National Map digital data, US TOPO map series, 2016 and 2017; the Wisconsin Department of Natural Resources, 2016; and Open Streetmap, 2018.



SYMBOLS

- Contact; dashed where approximate
- Syncline; concealed. Large arrowhead shows direction of plunge.
- Wave-cut scarp (Ordovician)
- Moraine crest
- 42 — Inclined bedding—Showing strike and dip
- Vertical bedding—Showing strike
- 65 — Overturned bedding—Showing strike and dip
- 78 — Cleavage—Showing strike and dip
- 10 — Mineral lineation—Showing bearing and plunge
- Well or drill core hole
- Rotosonic core hole from Carson and others (2020)
- Geoprobe core hole from Carson and others (2020)
- Well or drill core hole in cross-section view

INTRODUCTION AND SCOPE

The Baraboo quadrangle is located in the east-central Baraboo Hills. The southwestern corner of the quadrangle lies within the unglaciated Driftless Area of Wisconsin. The rest of the quadrangle has been modified by glacial processes. Devils Lake State Park and Parfreys Glen State Natural Area draw many outdoor enthusiasts to the map area. Additionally, geology students from across the Midwest visit the area to study its superb exposures of Precambrian and Paleozoic rocks and Quaternary sediments. This map is part of an effort to map the Baraboo Hills at 1:24,000-scale and builds on past work by subdividing and mapping members of the Baraboo Quartzite (Stewart and Stewart, 2020).

The Baraboo quadrangle is underlain by Proterozoic igneous and metasedimentary rocks overlain by Cambrian through Ordovician sedimentary rocks and Quaternary deposits. Paleoproterozoic granite and rhyolite and Paleoproterozoic through possibly Mesoproterozoic quartzite, slate, iron formation, and dolostone were metamorphosed to lower greenschist facies and folded into the Baraboo syncline. In early Paleozoic time, the resistant quartzite formed topographic highs—islands within stormy tropical seas (Dott, 1974)—that were eventually buried by sandstone and dolostone. Today this ancient topography has been partially exposed again as much of the lower Paleozoic section has been eroded away, leaving the resistant quartzite as topographic highs (see also Dalziel and Dott, 1970; Clayton and Attig, 1990). During the Quaternary, the Green Bay Lobe of the Laurentide Ice Sheet covered the eastern and northern parts of the quadrangle. In these areas, extensive deposits of till, outwash stream sediment, and lake sediment cover the bedrock in most places.

This map depicts the geologic units present 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. On this map, the Baraboo Quartzite is subdivided into three informal members (Xblc, Xblq, Xbuc) first described by Henry (1975) and a fourth quartzite and metapelite member (Xbqp) defined by Stewart and Stewart (2020). The overlying Proterozoic slate, iron formation, and quartzite units (Xs, Xf, and Xd) are known from historic drill records and drill core (Stewart and others, 2018); with the exception of the Dake Quartzite (Xd), which crops out in the north-central part of the quadrangle, these units are only shown in the cross section. Quaternary units and contacts were compiled and slightly modified from mapping by Clayton and Attig (1990) and updates from Carson and others (2020). The stratigraphy and structure shown on this map are also present in neighboring quadrangles. To maintain consistency in descriptions of the same features across multiple quadrangles, much of the stratigraphic and structural description is taken from Stewart and Stewart (2020) with slight modification. Where map units are continuous with units in adjacent quadrangles, unit descriptions were also taken from or modified slightly after Stewart and Stewart (2020).

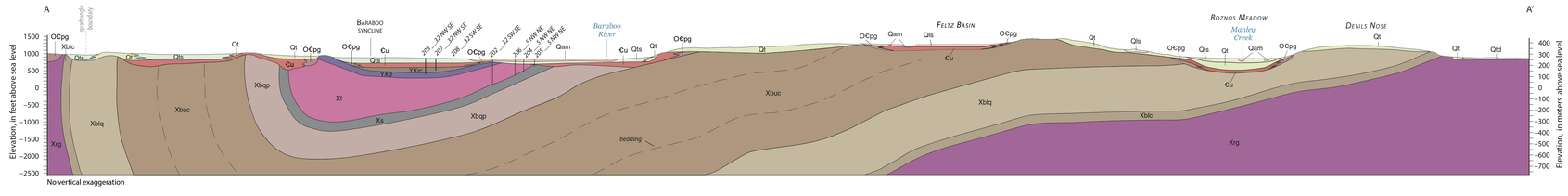
STRATIGRAPHY

The total thickness of the Baraboo Quartzite is around 2,000 meters (m) in the North Freedom quadrangle (Stewart and Stewart, 2020), and may thin slightly to around 1,900 m in the Baraboo quadrangle. Modifying Henry (1975), the Baraboo Quartzite is subdivided into four members that are mappable at 1:24,000-scale: The lower conglomerate and quartzite member (Xblc) is overlain across a sharp to gradational contact by the lower quartzite member (Xblq), which is overlain across a gradational contact by the upper quartzite and conglomerate member (Xbuc), which in turn is gradational with the overlying upper quartzite and metapelite member (Xbqp). The lower two members thin and the upper two members thicken from west (North Freedom quadrangle) to east (Baraboo quadrangle).

STRUCTURE

The Baraboo syncline is the dominant structure in the Baraboo quadrangle. Steeply south dipping to overturned north-dipping bedding characterizes the northern limb of the syncline, whereas the southern limb dips 10° to 35° to the north. The variation in dip angle likely defines low-amplitude folds superimposed on the southern limb. Although these folds are too subtle to map in the Baraboo quadrangle, similar structures are well developed and mappable in the North Freedom quadrangle to the west (Stewart and Stewart, 2020). The axial trace of the Baraboo syncline is buried beneath Paleozoic and Quaternary rocks and sediment throughout the quadrangle. Aeromagnetic anomaly data and historic core data (Stewart and others, 2018) were used to estimate the axial trace of the fold.

Cleavage in the Baraboo Quartzite typically strikes east-northeast and dips steeply to the north. Mineral lineations near the fold axis are generally subhorizontal. The cleavage is interpreted to be axial planar, and the subhorizontal lineations are interpreted to reflect a component of axis-parallel extension during folding (for example, Czeck and Ormand, 2007).



REFERENCES

Carson, E.C., Attig, J.W., Rawling, J.E., III, Hanson, P.R., Dodge, S.E., 2020, Chronology of advance and recession dynamics of the southern Green Bay Lobe of the Laurentide Ice Sheet, south-central Wisconsin, USA: Quaternary Research, v. 95, p. 142–153.

Clayton, L., and Attig, J.W., 1990, Geology of Sauk County, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 67, 68 p., 2 pls., scale 1:100,000.

Czeck, D., and Ormand, C.J., 2007, Geometry and folding history of the Baraboo Syncline: Implications for the Mazatzal Orogeny in the north-central U.S.: Precambrian Research, v. 157, p. 203–213.

Dalziel, I.W.D., and Dott, R.H., Jr., 1970, Geology of the Baraboo District, Wisconsin: A description and field guide incorporating structural analysis of the Precambrian rocks and sedimentologic studies of the Paleozoic strata: Wisconsin Geological and Natural History Survey Information Circular 14, 164 p., 7 pls., scale 1:62,500.

Dott, R.H., Jr.,1974, Cambrian tropical storm waves in Wisconsin: Geology, v.2, p. 243–246.

Henry, D.M., 1975, Sedimentology and stratigraphy of the Baraboo Quartzite of south-central Wisconsin: Madison, University of Wisconsin, M.S. thesis, 90 p.

Leith, A., 1935, The Precambrian of the Lake Superior region, the Baraboo District, and other isolated areas in the Upper Mississippi Valley, *in* Trowbridge, A.C., ed., Guidebook for Kansas Geological Society Ninth Annual Field Conference: Wichita, Kansas Geological Society, p. 320–332.

Lundqvist, J., Clayton, L., and Mickelson, D.M., 1993, Deposition of the Late Wisconsin Johnstown moraine, south-central Wisconsin: Quaternary International, v. 18, p. 53–59.

Marshak, S., Wilkerson, M.S., and DeFrates, J., 2016, Structural geology of the Baraboo District: An introduction, *in* Davis, R.A., Jr., Dott, R.H., Jr., and Dalziel, I.W.D., eds., Geology of the Baraboo, Wisconsin, area: Geological Society of America Field Guide, v. 43, p. 13–36.

Medaris, L.G., Jr., Singer, B.S., Dott, R.H., Jr., Naymark, A., Johnson, C.M., and Schott, R.C., 2003, Late Paleoproterozoic climate, tectonics, and metamorphism in the southern Lake Superior region and Proto-North America: Evidence from Baraboo interval quartzites: The Journal of Geology, v. 111, no. 3, p. 243–257.

Stewart, E.K., Brengman, L.A., and Stewart, E.D., 2021, Revised provenance, depositional environment, and maximum depositional age for the Baraboo (< ca. 1714 Ma) and Dake (< ca. 1630 Ma) quartzites, Baraboo Hills, Wisconsin: The Journal of Geology, https://doi.org/fw5f.

Stewart, E.D., and Stewart, E.K., 2020, Geologic map of the North Freedom 7.5-minute quadrangle, Sauk County, Wisconsin: Wisconsin Geological and Natural History Survey Map 506, scale 1:24,000.

Stewart, E.D., Stewart, E.K., Walker, A., and Zambito, J.J., IV, 2018, Revisiting the Paleoproterozoic Baraboo interval in southern Wisconsin: Evidence for syn-depositional tectonism along the south-central margin of Laurentia: Precambrian Research, v. 314, p. 221–239.

Van Wyck, N., 1995, Oxygen and carbon isotopic constraints on the development of eclogites, Holsnoy, Norway and major and trace element, common Pb, Sm-Nd, and zircon geochronology constraints on petrogenesis and tectonic setting of pre- and early Proterozoic rocks in Wisconsin: Madison, University of Wisconsin, Ph.D. dissertation, 280 p.

Weidman, S., 1904, The Baraboo iron-bearing district of Wisconsin: Wisconsin Geological and Natural History Survey Bulletin 13, 190 p.

Wisconsin Geological and Natural History Survey
DIVISION OF EXTENSION
UNIVERSITY OF WISCONSIN–MADISON

Wisconsin Geological and Natural History Survey
Kenneth R. Bradbury, Director and State Geologist
3817 Mineral Point Road, Madison, WI 53705 • 608/262.1705 • WGNHS.org

Open-File Report 2021-02 • 2021