THE BARABOO INTERVAL IN WISCONSIN

by

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ABSTRACT

Recent geologic mapping in Wisconsin has uncovered significant new data on the nature, extent, and tectonic setting of rock deposited during the Baraboo interval (1,760 to 1,500 Ma). It is now known that argillite, chert, conglomerate, micaceous quartzite, and low-grade iron-formation are important constituents of the sequence in addition to the well-known red quartzite. These other lithologies are widely distributed in the upper part of the sequence in southern Wisconsin. They commonly occur directly over older basement rock in central Wisconsin, suggesting that the thick, red quartzite may not have been deposited in this area.

Dating of intrusive rock and local stratigraphic relationships suggest that Baraboo interval sedimentation may have begun as early as 1,760 Ma, contemporary with the episode of felsic volcanism which followed the Penokean orogeny. Current evidence suggests that Baraboo interval sediment may have been deposited in a complex environment with facies distribution in part controlled by local uplift and basin development. The Baraboo interval sedimentary rock was deformed and metamorphosed probably around 1,630 Ma. The interval ended with emplacement of the Wolf River and related granitic rock (1,500 Ma).

INTRODUCTION

The term Baraboo interval was first used by Dott (1983) to designate the period of time (1,450 to 1,750 Ma) during which the well-known red quartzite, (Baraboo, Sioux, Barron) of the southern Lake Superior district was deposited. Greenberg and Brown (1983a, 1984) redefined Baraboo interval as a period of anorogenic igneous and sedimentary activity which followed the end of the Penokean orogeny (1,760 to 1,860 Ma) and ended with the emplacement of the Wolf River batholith (1,500 Ma). The time span of the Baraboo interval is based on dating of basement rock and igneous rock intrusive into Baraboo interval metasedimentary rock. Preliminary paleomagnetic studies (W. F. Kean, unpublished data) have shown promise as a means of distinguishing Baraboo interval rock from older and younger (Keweenawan) sedimentary rock.

Dott originally defined the Baraboo interval on the basis of the apparent age and lithologic similarity of the quartzite units. The Baraboo type quartzite, named for the best exposed and studied section at Baraboo, Wisconsin, is a unique rock type in the Precambrian of the Lake Superior region. Recent field studies in Wisconsin (Greenberg and Brown 1983b, 1984) have identified many new exposures of a diverse suite of metasedimentary rock. This suite includes argillite, bedded chert, micaceous and conglomeratic quartzite, and low-grade iron-formation. The rock overliesbasement ranging from 2,800 Ma to 1,760 Ma and are intruded by anorogenic igneous rock ranging from 1,760 Ma to 1,500 Ma which were apparently deposited along with the quartzite during this interval. This paper will briefly describe the distribution and character of the Baraboo interval rock in Wisconsin, and discuss their depositional history, correlation, and tectonic setting.

DISTRIBUTION OF BARABOO INTERVAL ROCK

With the exception of the Sioux Quartzite of southwestern Minnesota and eastern South Dakota, the best examples of Baraboo interval rock are exposed in Wisconsin. Other quartzite which is known from deep wells in Iowa, Nebraska, and Kansas may also be Baraboo interval rock (Anderson and Ludvigson, this volume). The informal type area for this rock is the Baraboo region of Sauk and Columbia Counties, Wisconsin (Dalziel and Dott, 1970). Similar red quartzite has long been known to occur in other areas of the state, most notably the Barron Quartzite in northwestern Wisconsin, the Waterloo Quartzite of Dodge and Jefferson counties, the McCaslin and Thunder Mountain Quartzites in northeastern Wisconsin, and an extensive area of red quartzite, argillite and iron formation in the subsurface of southeastern Wisconsin. Recent mapping in central Wisconsin (Greenberg and Brown, 1983b, 1985) has led to the recognition of numerous outcrops of Baraboo interval rock that were previously unknown or poorly known. The locations of known exposures and subsurface occurrences of these rocks in Wisconsin are shown in figure 1.

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ROCK OF THE BARABOO AREA

The Precambrian rock of the Baraboo area has been known and studied for many years (Irving 1872, 1877; Weidman 1904; Dalziel and Dott 1970; Dott 1983). The Baraboo Quartzite crops out in an elliptical pattern which outlines a syncline overturned to the south (fig. 2). Rhyolite and fragmental felsic volcanic rock which have been correlated with similar rock in the Fox River Valley and the subsurface of southeastern Wisconsin (Smith, 1978) have generally been interpreted as basement for the quartzite, although the actual contact is not exposed. The volcanic rock is part of an extensive anorogenic granite-rhyolite terrane (Smith, 1978) and has been dated elsewhere by U/Pb zircon method at 1,760 Ma (Van Schmus and others, 1975; Van Schmus, 1980). The stratigraphic succession at Baraboo consists of an undetermined thickness of rhyolite overlain by at least 1500 m of Baraboo Quartzite, 100 m of Seeley Slate, a dominantly argillaceous unit, and 300 m of the Freedom Formation, an iron-rich dolomite (Dalziel and Dott, 1970). Leith (1935) described two younger formations, the Dake Quartzite (65 m) and the Rowley Creek Slate. The Rowley Creek Slate is known only from early iron exploration records.

The lower 1500 meters of section at Baraboo consists of the typical red quartzite described by Dott (1983). Weidman (1907) described an extensive basal conglomerate developed on top of the underlying rhyolite. Most of the coarse fragmental rock such as those exposed at the Lower Narrows and Caledonia Church (fig. 2) are now known to be volcanic breccia belonging to the rhyolite sequence (Smith, 1978). The lowermost beds of the quartzite are locally pebbly, but do not contain much recognizable fresh volcanic debris. However, several of Weidman's thin sections taken from several hundred meters above the base of the section in the north range, (Greenberg and Brown, 1983) contain what are probably volcanic rock fragments. The exact nature of the basal contact is not known, although outcrops of both units exposed less than 15 meters apart suggest an abrupt change from rhyolitic fragmental rock to mature quartz sandstone.

The sedimentology of the quartzite at Baraboo has been discussed by Henry (1975) and Dott (1983) who concluded that sedimentary characteristics are most consistent with "braided fluvial and/or littoral and inner shelf deposition." This environment graded upward into a marine environment at the time of deposition of the argillite and carbonate of the Seeley and Freedom Formations. Dott (1983) presents convincing sedimentological arguments for the similarity and probable correlation in the broad sense of the Barron and Sioux Quartzites, with the quartzite at Baraboo.

Argillaceous rock is most abundant in the upper part of the Baraboo section. However thin argillite beds are known to occur throughout the lower 1500 meters of quartzite. Beds of argillite up to several centimetres in thickness occur near the base of the quartzite at Baxter Hollow on the south limb of the syncline, and increase in abundance and thickness upwards to the Highway 12-Skillet Creek road cut (Greenberg and Brown 1983; Hempton, this volume) where they are abundant and are commonly up to 2 m thick. No other outcrops of quartzite occur on the south limb to the north of Skillet Creek (fig. 2). The core of the syncline is composed of the Seeley Slate and younger formations.

The Seeley Slate was described by Weidman (1904) from core drilled during iron exploration and from mine workings. The Seeley is commonly gray with bedding marked by slight variation in color and texture. Weidman reported that a well developed slaty cleavage at high angle to bedding is commonly present. Wiedman described the contact with the underlying Baraboo quartzite as conformable and the contact with the overlying Freedom Formation as gradational.

The Freedom Formation was extensively explored for commercial iron ore in the early 1900s. The only complete description of this unit is that of Weidman (1904). Schmidt (1951) described the subsurface geology of the Freedom Formation based on Weidman's notes and iron company records. A petrographic description of core samples from the Cahoon Mine site south of Baraboo is discussed by Geiger (this volume). The Freedom Formation consists of a variety of lithologies, ranging from relatively pure slate and dolomite to ferruginous slate and dolomite and to chert. The iron ore was largely hematite. Much of the waste rock consisted of jasper (ferruginous chert), slate and ferruginous dolomite. In describing the Freedom formation in a letter Van Hise stated that the more siliceous types closely resembled any other Lake Superior type iron-formation. The dolomitic members of the Freedom Formation are unique among Baraboo interval rock in Wisconsin, but the ferruginous slate, bedded ferruginous chert, and lean cherty iron formation are similar to rock which occurs in association with Baraboo-type quartzite elsewhere, particularly in central Wisconsin and in the subsurface of southeastern Wisconsin

WATERLOO--SOUTHEAST WISCONSIN SUBSURFACE

Quartzite crops out along Stony Branch Creek and the Crayfish River east of the town of Waterloo (fig. 3). The southernmost outcrops, north of Lake Mills, are purple to red quartzite with well developed cross bedding. This quartzite is identical in appearance, texture, and composition to quartzite in the lower 1500 m of the Baraboo section. At Portland quarry and in the area east of Waterloo the quartzite is interbedded with argillite and pebble conglomerate. At Portland (fig. 3) all lithologies show evidence of recrystallization and metamorphism. The quartzite becomes gray in color and takes on a coarse mosaic texture. The scattered 10- to 20-cm thick argillite beds contain andalusite and iron-rich chloritoid. Geiger and others (1983) identified two stages of metamorphic mineral growth, an early mineral assemblage consisting of muscovite, quartz, chlorite, andalusite, chloritoid with or without plagioclase and hematite which they

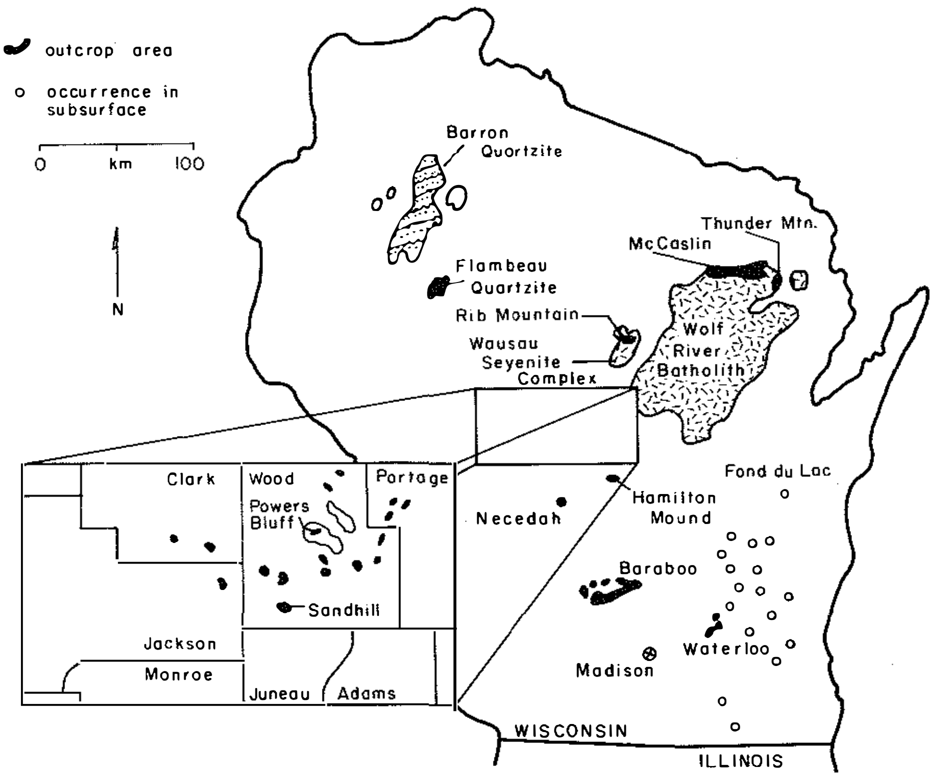

Figure 1.--Map showing locations of exposure and subsurface occurrences of Baraboo interval rock in Wisconsin.

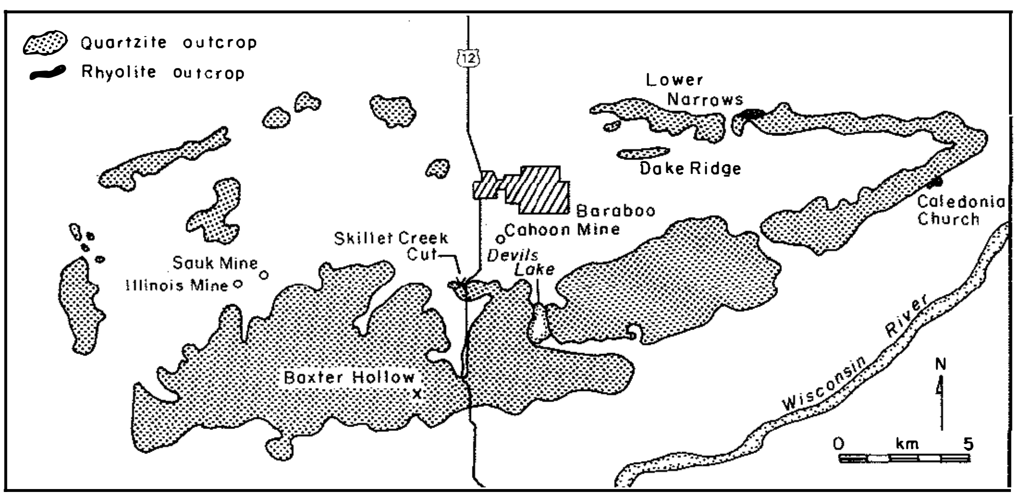

Figure 2.--Map of the Baraboo area showing location of outcrop and mines.

attribute to static growth at greater than 3.8 Kb and 550 °C. They also identified a later overprinting assemblage of coarse chlorite and muscovite. Both metamorphic events were static recrystallization which occurred after deformation.

A structural study of the Waterloo area by Brandon (1983) identified two sets of folds. Early northeast plunging mesoscopic folds were reoriented by later broad, easterly plunging, macroscopic folds. The second folds of Brandon are major structures several kilometers wide, which are defined in the subsurface by basement topography and aeromagnetic trends. These major folds are of similar magnitude and orientation and may be equivalent to the Baraboo Syncline. Brandon's study agreed with Geiger and others (1983) that folding was followed by static metamorphism.

Pink-granitic pegmatite dikes up to 1 m across cut quartzite exposed on Rocky Island in the Crayfish River northeast of Waterloo (fig. 3). The pegmatite has been dated at 1,440 Ma by the Rb/Sr method (Aldrich and others, 1959). This age for the pegmatite and an Ar/Ar release age of 1,450 to 1,500 Ma on mafic dikes in drill core taken at Portland Quarry (Guidotti, unpublished data) establishes a minimum age for the quartzites that coincides with the age of emplacement of the Wolf River batholith in central Wisconsin. Thermal metamorphism associated with intrusion of dikes at around 1,500 Ma may account for the static metamorphic events found by Brandon (1983) and Geiger and others (1983). Further evidence of intrusive activity is found in the northernmost outcrop of this area near Reeseville where hydrothermal quartz breccia zones similar to those described at Necedah and Hamilton Mounds (Greenberg this volume) cut the quartzite.

Quartzite is encountered in deep wells throughout southeastern Wisconsin, (Brown and Greenberg 1983; Thwaites 1931, 1940). The dominant material is pink to purple quartzite with minor amounts of argillite and iron formation. Petrographically, these rocks are similar in all aspects to the rocks of the Baraboo section. The quartzite generally defines buried topographic highs similar to the Baraboo Range, which commonly influenced distribution of facies within the overlying Cambrian sandstone (Thwaites 1940). A prominent bedrock high surrounds the Waterloo outcrops (Smith, 1978). Quartzite is the dominant basement rock over a broad area as far north as Fond du Lac (fig. 1).

HAMILTON MOUND

The quartzite at Hamilton Mound in Adams County (fig. 1) is a typical Baraboo-type quartzite which has been intruded by granite (Greenberg and Brown, 1983b; Taylor and Montgomery, this volume). Away from the granite the quartzite has the color, texture, and sedimentary structures typical of the Baraboo Quartzite. Near the granite contact an extensive zone of alteration is developed in which the two rock types grade into each other (fig. 4) over an interval of 10 to 12 m (Greenberg and Brown, 1983b). A structural map by Ostrander (1931) identified two synclines and an intervening anticline in the Hamilton Mound outcrop. The macroscopic folds trend N. 80° W., roughly parallel to the axis of the Baraboo syncline.

The granitic intrusion is discussed by Taylor and Montgomery (this volume). Two notable features seen at Hamilton Mound and other locations, where Baraboo-type quartzite is intruded by granite, are the breccia zones consisting of angular quartzite fragments in a white vein quartz matrix and the alteration of the red color to a greenish-yellow by reduction of iron (Greenberg, this volume).

Preliminary U/Pb zircon studies (W.R. Van Schmus, unpublished data) suggest an age of 1,760 Ma for the granite. If this age is confirmed, it is significant in that this provides a minimum age for the quartzite. An age of 1,760 Ma would imply a time of deposition closely following the end of the Penokean orogeny and contemporary with rhyolite volcanism in south-central Wisconsin.

NECEDAH

Precambrian quartzite is exposed in a large bluff and as several smaller outcrops within the town of Necedah in Juneau County (fig. 1). The quartzite in the smaller exposures is gray to pink in color and is nearly identical in composition and texture to other Baraboo-type quartzite. Recrystallization has destroyed most primary textures and structures with the exception of poorly preserved cross bedding. Recent excavations in a large quarry near the west end of the bluff have exposed some ferruginous argillite, which appears to strike east west and dip steeply (80°) to the north. Most structures in the quarry exposure have been destroyed by brecciation and quartz veining associated with a granitic intrusion of unknown age.

Large pieces of intrusion breccia (fig. 5) which consist of quartzite fragments in a granitic matrix have been observed in the quarry. The quartzite fragments are green in color indicating iron reduction similar to that which occurred near the intrusive contact at Hamilton Mound. The actual intrusive contact is not exposed due to back filling and stockpiled materials, but the in-

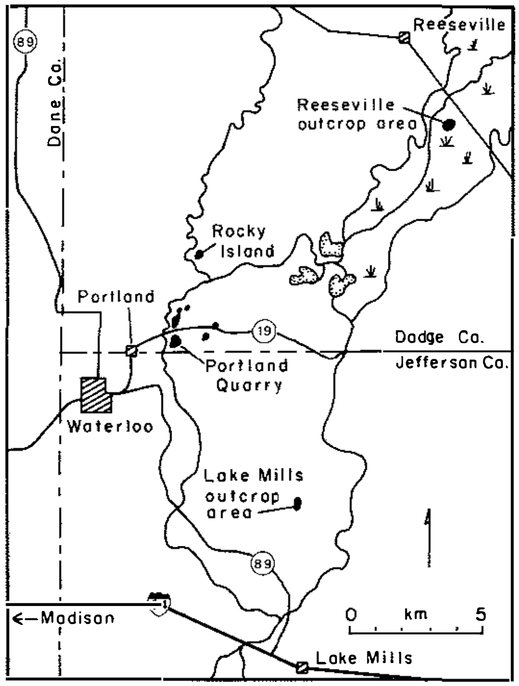

Figure 3.--Map of the Waterloo area showing location of quartzite outcrop.

trusion breccia along with extensive quartz breccia zones, (Greenberg, this volume) and hydrothermal minerals such as muscovite and feldspar confirm the presence of an intrusion. Early drilling records (S. Wiedman, field notes) reported diorite and granite bedrock in wells located within 500 m of the Necedah outcrops.

The lithologic similarity of the quartzite to that of Baraboo, and the similarity of the ferruginous argillite to that associated with other Baraboo interval quartzite argues for their inclusion in this group.

CENTRAL WISCONSIN

Quartzite, chert, argillite, and ferruginous metasediment which closely resemble rock in the Baraboo section are abundantly exposed in Wood and Portage counties (Greenberg and Brown, 1985). Isolated exposures of quartzite, chert, and brecciated rhyolite with extensive quartz veining also occur in Clark and Jackson counties. The best exposures occur in the area of Powers Bluff County Park and in the Sandhill Wildlife Refuge at Babcock (fig. 1).

Powers Bluff is an elongate ridge consisting of fine-grained quartzite (fig. 6) best described as a bedded chert, (Greenberg and Brown, 1983b). Bedding is commonly 5 to 10 cm thick, and the rock varies from nearly white to dark bluish-gray to red in color. In thin section (fig. 7) the chert is aphanitic, consisting of fine-grained quartz with hematite as the dominant opaque mineral. The chert is similar in texture to some of the chert described by Weidman (1904) from the Freedom Formation. The common occurrence of this distinctive chert in glacial deposits and the abundance of small outcrops suggests that this unit was once widespread in central Wisconsin.

A small quarry to the southeast of Powers Bluff (fig. 9) exposes bedded chert and up to 20 m of argillite. The argillite is finely laminated (5 to 10 mm) and varies in color from brown to greenish gray to black. The argillite is similar in appearance, texture, and composition to the ferruginous argillite at Necedah and in the Freedom Formation at Baraboo. Large-scale bedding, marked by color variation, is on the scale of 40 to 50 cm. Preliminary X-ray analysis (S.W. Bayley, unpublished data) indicates that the black zones are high in amorphous carbon, and that and that the red zones are highly ferruginous. Quartz and kaolinite are dominant materials in the argillite, suggesting a low grade of metamorphism. The contact between the chert and argillite is gradational with thin 5 to 10 cm beds of chert and isolated chert nodules occurring in the argillite.

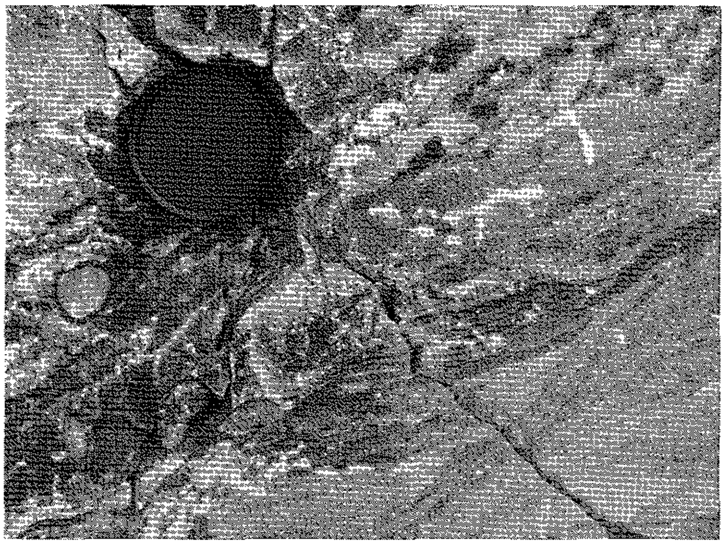

Figure 4.--Distorted bedding and inclusion with reaction rim in quartzite from the intrusive contact at Hamilton Mound. Lens cap is 5 cm in diameter (from Greenberg and Brown, 1983b).

In a road cut southeast of the quarry (fig. 9) chert and argillite occur in association with more typical, red, Baraboo-type quartzite. Quartzite ranging from quartz arenite to micaceous pebbly conglomerate occurs in numerous small outcrops within 2 to 3 km of Powers Bluff. This association and the similarity of the argillite to the Seeley and Freedom Formations suggests that these rocks are Baraboo interval metasediment.

No detailed structural work has been done in the Powers Bluff area, and no reliable top indicators have been found to establish relative ages of the chert, argillite and quartzite. Bedding strikes N. 60° to 80° W., parallel to the trend of the bluff. Dips vary from near vertical to 80° north or south. Local variation in strike suggests gentle folding about steeply plunging axes. A distinct cleavage trending N. 20° E. is evident throughout the argillite units. These rocks have been folded but show evidence of only very mild metamorphism. Preservation of fine lamination in the argillite (fig. 8) and the lack of significant recrystallization in the chert suggests low temperature and pressure. The low-grade rock of the quartzite-chert-argillite sequence stand in marked contrast to the high-grade (amphibolite faces) Penokean and Archean basement rock exposed nearby (Greenberg and Brown, 1985). The basement/cover relationship is apparent in that Baraboo-type rocks occur on knobs and hills with the high-grade rock in low areas, often only tens of meters apart.

Baraboo-type, red quartzite occurs in intimate association with felsic metavolcanic rock at the Sandhill Wildlife Refuge (Greenberg and Brown 1983). The volcanic rock consists of flow-banded rhyolite and felsic fragmental rock containing rhyolite clasts in a matrix of quartz-sericite phyllite. The large outcrop on North Bluff consists of massive and fragmental rhyolite (fig. 10). A small exposure in a quarry 0.5 km to the east of the bluff consists of rhyolite in direct contact with quartzite. The quartzite varies from a micaceous red quartzite containing up to 25 percent sericite to a pebble conglomerate. These micaceous quartzite, which are common in the region, are similar in texture and composition to the Dake Quartzite in the upper part of the Baraboo sequence. The quartzite and rhyolite appear to be in conformable contact with no evidence of a major unconformity. A common foliation suggests that both underwent deformation and low-grade metamorphism at the same time.

Micaceous quartzite grading to quartz/sericite phyllites occurs at several other localities in Wood and Portage Counties, (Greenberg and Brown, 1983b, 1985). Notable occurrences are in a quarry northwest of Vesper and in two quarries near Veedum, southwest of Pittsville (Greenberg and Brown, 1983b), where the micas are high in chromium (S.W. Bayley, unpublished data). The high chromium content suggests local derivation from chromite-bearing ultramafic rock which occurs in the basement rock of the area. At Vesper the micaceous pebbly quartzite overlies granite dated at 1,900 Ma (Van Schmus, 1984) and grades upward into a clean buff to red quartzite similar in appearance to other Baraboo interval quartzite. The Rb/Sr isotopic system in the granite shows evidence of disturbance at 1,500 Ma (C. Montgomery, unpublished data).

Figure 5.--Quartzite breccia cemented by white vein quartz in quarry at Necedah Bluff, Juneau County (from Greenberg and Brown, 1983b).

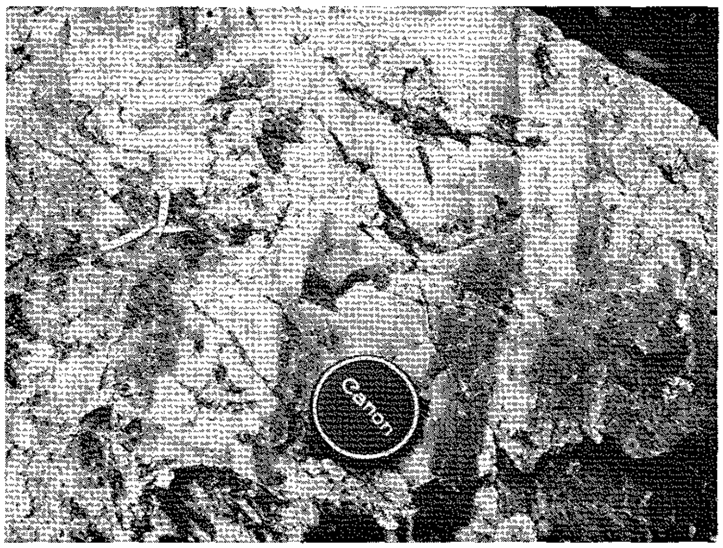

Figure 6.--Bedded chert at Powers Bluff County Park, Wood County. Lens cap is 5 cm in diameter (from Greenberg and Brown, 1983b).

Little systematic work has been done on the structural geology of the Baraboo interval rock of central Wisconsin. Reconnaissance work has shown that the rock is folded, generally about shallow plunging, roughly east-west trending axes, a similar trend to the Baraboo syncline and the macroscopic folds at Waterloo and Hamilton Mound. The relatively simple style of deformation and low metamorphic grade suggest that the rock is younger than the highly deformed and metamorphosed Archean and Penokean basement rock. Retrograde metamorphism apparent in the older rock of the area (R. Maass, unpublished data) may be related to the event which deformed the Baraboo interval rock, but no definite connection has yet been established.

RIB MOUNTAIN

The quartzite at Rib Mountain and smaller outcrops on nearby Mosinee and Hardwood Hills (fig. 1) are actually large xenoliths in the 1,500 Ma Wausau complex (Dockstader, this volume). Ansfield (1967) described ripple marks and cross bedding, but original structures and textures are largely obliterated by recrystallization. Laberge and Myers (1984) argued that these quartzite xenoliths represented basement quartzite caught up in the syenite of the Wausau complex. They based their reasoning on metamorphic textures and the presence of sillimanite which they attributed to regional metarmorphism in the early Proterozoic. In the absence of other criteria to establish age this interpretation cannot be accepted. Sillimanite is known to occur in other Baraboo-equivalent quartzite associated with 1,500 Ma intrusive rock (Olson, 1984; Greenberg and Brown, 1984; Maass and others, 1985). Further evidence is presented by Dockstader (this volume) which suggests that the quartzite blocks in fact rotated downward into the intrusive granite and syenite. An additional suggestion of Baraboo affinity is the occurrence of meta-catlinite layers in the Rib Mountain quartzite.

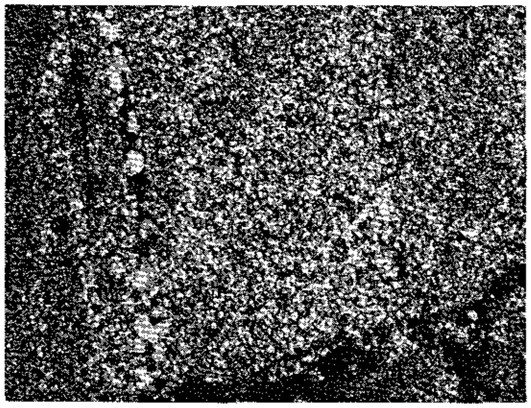

Figure 7.--Photomicrograph of bedded chert, Powers Bluff County Park. Rock consists almost entirely of fine quartz grains with minor iron oxides. Field of view is 8 mm in long dimension (from Greenberg and Brown, 1983b).

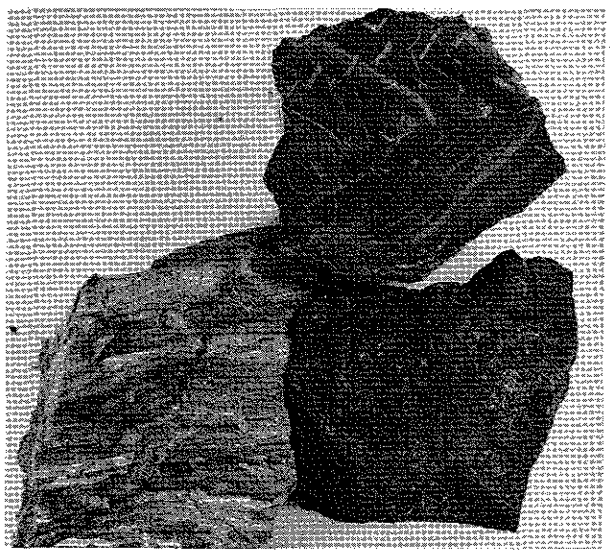

Figure 8.--Hand specimens of argillite interbedded with chert at Powers Bluff. Clockwise from top: folded ferruginous argillite; carbonaceous argillite; and banded, kaolin-rich argillite. Specimens are approximately 10 cm in diameter (from Greenberg and Brown, 1983b).

McCASLIN QUARTZITE

The McCaslin Quartzite of northeastern Wisconsin is similar in lithology and texture to other quartzite included in the Baraboo interval group. The McCaslin Quartzite overlies metavolcanic rock of presumed Penokean age, and is intruded by rock of the 1,500 Ma-old Wolf River batholith. Olson (1984) described the petrology of this unit at McCaslin Mountain, Thunder Mountain, and Deer Lookout Tower in Forest and Oconto Counties (fig. 1). Quartzite is the dominant lithology, although a thin basal pebble conglomerate is present. Total thickness is at least 1220 m. Olson concluded that the McCaslin Quartzite was deposited in a braided fluvial environment, similar to that proposed for the Baraboo Quartzite by Dott (1983). True argillite is present only as thin, phyllitic partings in the McCaslin Quartzite.

As at Rib Mountain, original texture in the McCaslin has commonly been obliterated by contact metamorphism from the Wolf River batholith which produced metamorphic sillimanite, garnet, chloritoid, and andalusite in the more argillaceous beds.

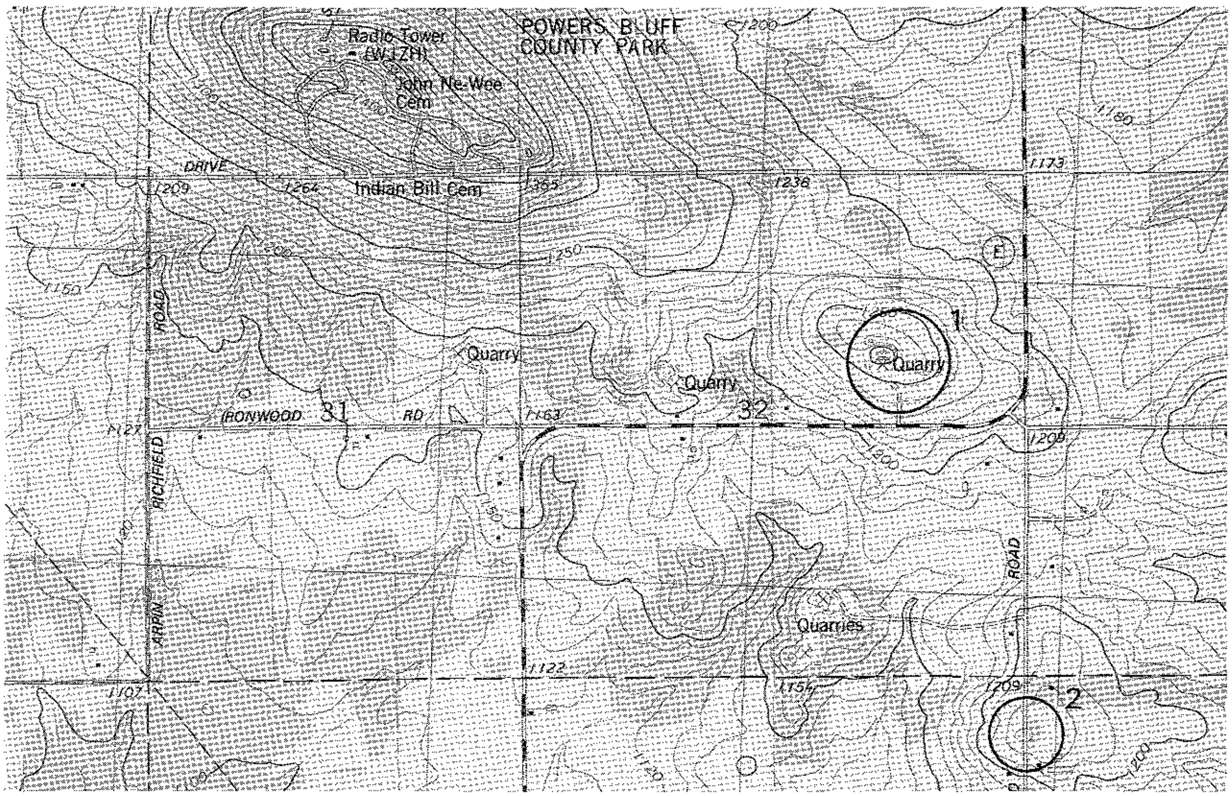

Figure 9.--Map showing location of outcrop in the Powers Bluff area, Wood County: 1, location of quarry in which argillite/chert sequence is exposed; and 2, location of road cut which exposes chert, argillite, and quartzite (from Greenberg and Brown, 1983b).

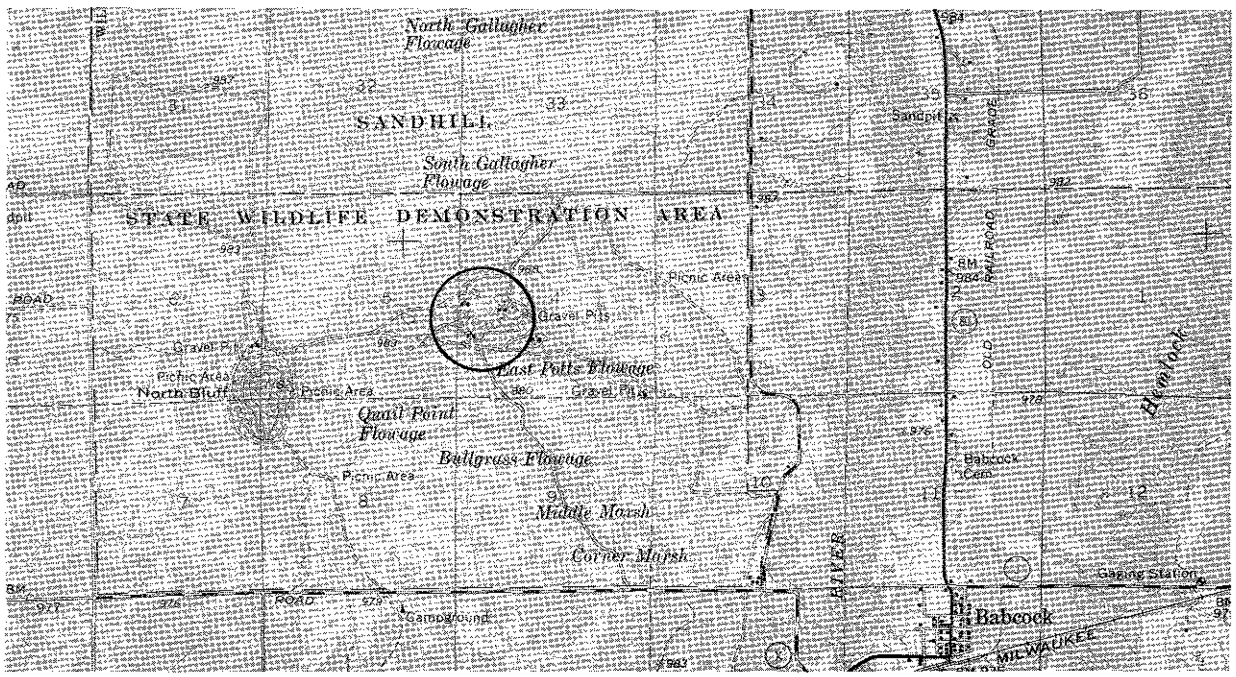

Figure 10.--Map of the Sandhill Wildlife Refuge area, Wood County. Quartzite and rhyolite are exposed in the gravel pits. North Bluff is a large outcrop of rhyolite (from Greenberg and Brown, 1983b).

BARRON AND FLAMBEAU QUARTZITES

The Barron and Flambeau Quartzites are the westernmost exposures of Baraboo-type quartzite in Wisconsin. The Barron covers a large area of Barron, Rusk, Sawyer, and Washburn Counties. The Flambeau crops out in Chippewa and Rusk Counties (fig. 1).

Johnson (1985) described the Barron Quartzite as a fine-grained, red to buff, quartz arenite with little variation except for scattered zones of quartz pebbles, a thin basal conglomerate, and 10- to 20-cm thick beds of catlinite in the upper part. Johnson concluded on the basis of a sedimentologic study that the Barron Quartzite was deposited in a braided fluvial environment superseded by a marine shelf environment, similar to that proposed for other Baraboo-type quartzite in Wisconsin (Dott, 1983; Greenberg and Brown, 1984). A shallow marine environment for the upper part of the Barron is suggested by bimodal, bipolar paleocurrent directions. Johnson and Dott both found little or no evidence for folding or metamorphism in the Barron, although northeast-trending faults are common. The Barron overlies granitic and volcanic rock which may be in part as young as 1,760 Ma (M.G. Mudrey, Jr., unpublished data) and is intruded by diabase dikes of presumed Keweenawan age.

The Flambeau Quartzite, which forms a prominent ridge, is located only 30 km to the south of the outcrop edge of the Barron (fig. 1) but is different in several significant ways (Campbell, 1981; this volume). The Flambeau is predominantly a quartz arenite, similar to the Barron and other Baraboo types, but is more conglomeratic, containing pebble conglomerate throughout. Campbell concluded that the Barron and Flambeau Quartzites were lithologically similar and probably shared a common source terrane. He also notes that the Flambeau is folded, whereas, the Barron is flat lying and nearly undeformed. The Flambeau is nearly 800 m thick. Only 200 m of Barron section has been documented; the original thickness of this unit may have been greater.

The Barron and Flambeau present a problem in direct correlation, which is typical of other Baraboo interval sediments. Lithologic and sedimentological evidence argue for correlation in the broad sense. What is known of the basement rock suggests that both are post-Penokean, implying that they belong in the Baraboo interval. It is agreed by most workers that the Barron and Flambeau are probably both members of the Baraboo-interval group of metasedimentary rock, but whether they are different sedimentary sequences deposited in that interval or whether they are equivalent lateral facies affected differentially by the tectonic event that deformed the Baraboo-interval rock, is a question yet to be resolved (Greenberg and Brown, 1984).

STRATIGRAPHY AND SEDIMENTATION

Discontinuous exposure and the lack of fossils or other stratigraphic markers makes correlation among the units in the strict sense impossible. However, the lithologic similarity within the group, and the relationship of the rock to dated units strongly supports the conclusion that they are related and that they were deposited during the roughly 250 m.y. period now called the Baraboo interval.

Available sedimentological data indicate that the characteristic red-quartzite sequences were largely fluvial deposits. Detailed studies of the Baraboo and Barron Quartzites (Dott, 1983; Johnson, 1985) suggest that the fluvial environment later changed to shallow marine conditions. At Baraboo argillite and chemical sediment dominate the upper part of the section. In the Barron, argillite is much less common, but bimodal and bipolar paleocurrent directions suggest a tidal influence in the upper beds (Johnson, 1985). The Baraboo and Barron areas are the only places where a sufficiently complete section is preserved for the fluvial/marine transition to be observed. All other exposures in Wisconsin are relatively small, and probably represent only a partial stratigraphic section. The majority of quartzite occurrences described consist of the fluvial facies, which evidently was present over much of Wisconsin at one time.

The marine facies (argillite, carbonate, chert) are known only from Baraboo, central Wisconsin, and the subsurface of the southeast. The marine facies may have been present at the top of the section throughout the entire area of quartzite deposition, but they have not been preserved. The similarity of chert and argillite in central Wisconsin to rock of the Freedom and Seeley Formations at Baraboo suggests that this facies was deposited as far north as Wood and Portage counties. Their absence in the northern areas of quartzite (Rib Mountain, McCaslin, and Barron) suggests that they were either not deposited or were removed by erosion. The transition from fluvial to marine conditions in the Barron Quartzite without significant argillite deposition suggests that these lithologies might never have been deposited in the north and west.

Greenberg and Brown (1984) also suggested a model which involved multiple sequences separated by major unconformities. In this model (fig. 11c) the chert, volcanogenic sediment and argillite of central Wisconsin could be part of an early sequence, eroded and later covered by marine transgression as in model 1. Later uplift and erosion would have removed the overlying upper sequence in this area. However, no major regional unconformities have been identified in the sequence. There is no evidence for more than one major episode of deformation and metamorphism in the rock. The only evidence in support of a multiple sequence is the suggested unconformity between the Dake and Freedom Formations at Baraboo and the difference in deformational intensity between the Barron and Flambeau Quartzites. Neither of these is, however, sufficient to establish two depositional, tectonic sequences in the absence of other data. The unconformity below the Dake Quartzite is not well documented and may represent only a local change in source or fluctuation in sea level. The Flambeau-Barron problem may reflect only local variation in deformational intensity, a question which cannot be resolved at present without more detailed structural work and dating. Considering the limited preservation of the rock and the length of the Baraboo interval, the possibility of multiple sedimentary cycles certainly cannot be eliminated at this time.

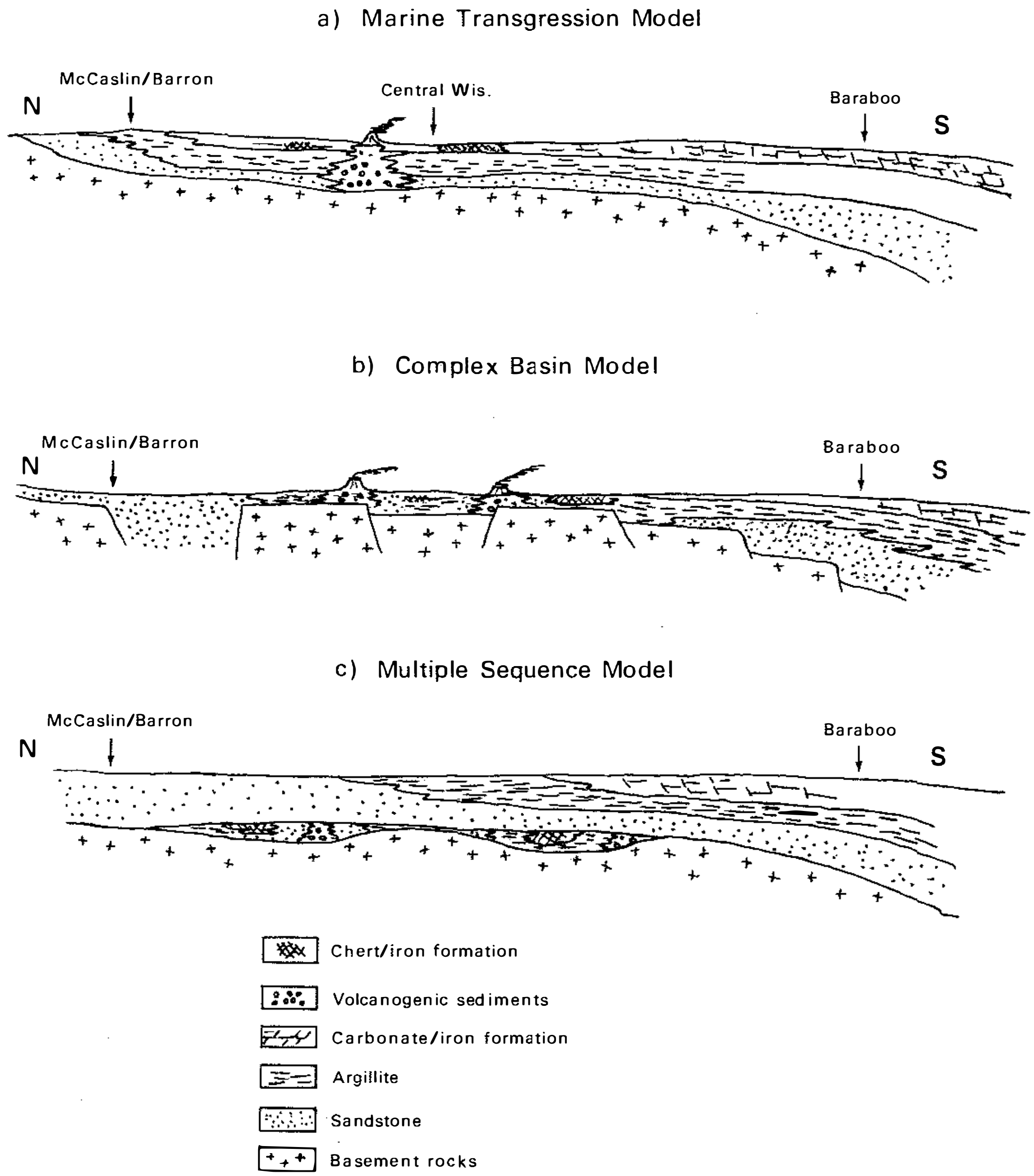

Figure 11.--Possible models for deposition of the Baraboo interval rock of Wisconsin (from Greenberg and Brown 1983b).

TECTONIC SETTING OF THE BARABOO INTERVAL

Greenberg and Brown (1984) presented three possible depositional models for Baraboo interval sediment in Wisconsin. The first model (fig. 11a) consisted of a simple south to north marine transgression, which resulted in a fining-upward sequence. This is essentially the model suggested by Dott (1983) based on his analysis of stratigraphic and sedmentological data from the Baraboo, Barron, and Sioux Quartzites. This model implies increased subsidence to the south with resulting accumulation of a thicker section in the Baraboo area. It is also consistent with the absence of the marine facies in the far north. However, the presence of argillite and chert deposited directly over older basement in much of central Wisconsin, particularly in the absence of a significant thickness of quartzite, suggests that it may be too simplistic.

A simple model that is consistent with existing data is the complex basin model (fig. 11b) of Greenberg and Brown (1983, 1984). Marine transgression in combination with local topographic highs within the basin of deposition, possibly the result of block faulting, controlled facies distribution. This model would provide for the accumulation of thick fluvial quartzite in the north and south and the relative absence of fluvial quartzite in central Wisconsin, where marine facies were deposited directly on top of basement highs at the time of maximum transgression. A similar model involving fault controlled basins has been suggested for the Sioux Quartzite by Morey (1984). This model allows for restricted basins of accumulation for the McCaslin, Barron, Rib Mountain, and other fluvial quartz-arenite sequences in the north, and the similar Baraboo sequence in the south. The positive area in central Wisconsin did not receive these deposits, but was covered by locally derived micaceous and arkosic quartzite with minor local volcanogenic contributions as in the case of the interbedded rhyolite at Sandhill. After the fluvial quartzite sequence was deposited in local basins the positive area in central Wisconsin was covered by the transgressing marine environment. Argillite and chemical sediments were deposited in this region and at the top of the Baraboo sequence at this time. Depending upon how far north marine conditions reached, similar rock may have at one time covered the McCaslin and Barron Quartzites and later been removed by erosion. Alternatively, the fluvial to marine transition in the north may have been marked only by the change from fluvial to tidal sandstone as occurred in the Barron Quartzite.

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