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Revisiting the Paleoproterozoic Baraboo interval in southern Wisconsin: Evidence for syn-depositional tectonism along the south-central margin of Laurentia

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ABSTRACT

The Statherian Baraboo Quartzite (1710–1650 Ma) is present in the Baraboo Ranges, Wisconsin, USA. It is one of several isolated quartzites outcropping across the southern Lake Superior region. Collectively, these quartzites are known as Baraboo interval quartzites, and they record a history of basin development followed by regional deformation along the south-central Laurentian margin. Baraboo interval stratigraphy above the Baraboo Quartzite in the Baraboo Ranges is unresolved, limiting understanding of the style and history of basin formation, sedimentation, and deformation, as well as correlation between regional quartzites.

New Precambrian geologic mapping within the core of the Baraboo syncline, Baraboo Ranges, WI, confirms early interpretations of local stratigraphy. The Baraboo interval section includes two upward-fining sequences separated by an angular unconformity. The lower sequence comprises the Baraboo Quartzite, Seeley Slate, and Freedom Formation. The upper sequence comprises the Dake Quartzite and Rowley Creek Slate. The depositional age of the upper sequence is poorly constrained, but could be nearly 200 million years younger than the underlying units. U-Pb detrital zircon ages for the lower conglomeratic Baraboo Quartzite and the Dake Quartzite are dominated by nearby basement ages between 1800 and 1750 Ma and 1900–1835 Ma, suggesting a restricted drainage system tapping proximal basement sources. Subsidence modeling of the lower sequence demonstrates at least 1.28 km of subsidence is required to generate the accommodation necessary to deposit the Baraboo Quartzite, Seeley Slate and Freedom Formation. These results support a model where deposition of the lower sequence between ca. 1710–1650 Ma occurred along a tectonically active plate margin. The lack of coeval magmatism in the Baraboo interval suggests deposition did not occur in a convergent, arc setting. However, coeval orthoquartzite deposition in Colorado, Arizona, and New Mexico along the southwestern margin of Laurentia (1700–1650 Ma) occurred synchronous with arc volcanism, requiring a component of plate margin convergence to the southwest. To reconcile these differences, a model where the entire southern margin of Laurentia between 1710 and 1650 Ma was dominated by strike-slip motion is favored, varying from highly oblique convergence in the southwest to dominantly strike-slip motion in the southern Lake Superior region.

1. Introduction

Southern Laurentia records a complex history of continental growth through arc collision, accretion, and continental stabilization (e.g. Whitmeyer and Karlstrom, 2007). Unlike the southwestern margin of Laurentia, which has undergone Mesozoic and Cenozoic shortening and extension, south-central Laurentia has remained tectonically stable for the past billion years. In the southern Lake Superior region of the USA, tectonic stability has preserved the complex history of Laurentian assembly, but has resulted in subdued surface topography and deposition of Phanerozoic sediments that hinder direct observation of Precambrian rocks.

Between ca. 1750–1630 Ma the southern Lake Superior region experienced extreme weathering and significant sediment deposition, and this episode of weathering and sedimentation is known as the Baraboo interval (Medaris et al., 2003). Today the Baraboo interval is recorded by a series of isolated quartzite outcroppings across the region. These outcrops have been fundamental in understanding the history of growth and stabilization of Laurentia, as well as Proterozoic climate. In the southern Lake Superior region, USA, Baraboo interval quartzites were deposited along the south-central margin of Laurentia (Fig. 1a) over basement provinces including the Archean Superior Province, the

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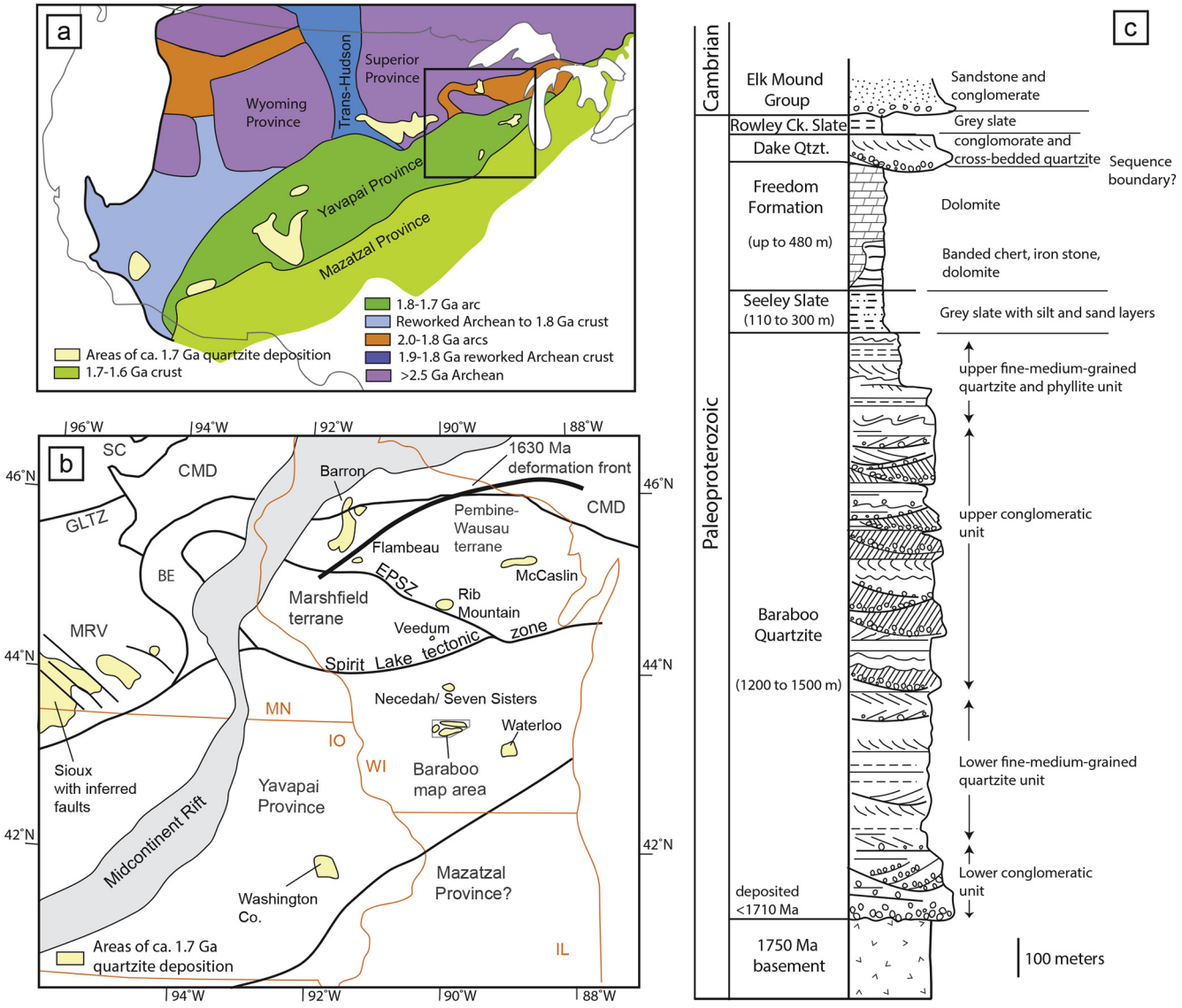

Fig. 1. a) Terrane map of Paleoproterozoic and Archean provinces in southern Laurentia. Generalized zones of ca. 1.7 Ga sedimentation are highlighted. Modified from Whitmeyer and Karlstrom (2007). b) Regional map of the southern Lake Superior region showing map area, terrane boundaries, and locations of Baraboo interval deposition. SC = Superior craton, GLTZ = Great Lakes tectonic zone, MRV = Minnesota River Valley promontory, BE = Becker embayment, CMD = Craton margin domain, EPSZ = Eau Pleine Shear Zone. Geology from the NICE Working Group (2007) and Chandler and Morey (1992), and Medaris et al. (2011). c) Stratigraphic column for the Baraboo interval in the Baraboo Hills area of southern Wisconsin, modified from Medaris et al. (2011) Thicknesses for the Baraboo through Freedom Formation are noted below the unit name on the stratigraphic column. Thickness of the Dake Quartzite is 65 m and Rowley Creek Slate is at least 45 m.

Penokean orogenic belt (ca. 1.87–1.835 Ga; Van Schmus, 1980), and the Yavapai terrane (1.8–1.75 Ga; NICE Working Group, 2007). Baraboo interval quartzites include the Sioux quartzite of South Dakota and Minnesota, the Washington County quartzite of Iowa, and the Barron, Flambeau, Necedah and Seven Sisters, Rib Mountain, McCaslin, Baraboo, and Waterloo quartzites of Wisconsin (Fig. 1b). Their supermature composition is interpreted to have resulted from deposition in a warm, humid environment under conditions of extreme chemical weathering, and their red-bed character is interpreted as requiring a pre-1630 Ma oxidized atmosphere (Dott, 1983; Ojakangas and Weber, 1984; Southwick et al., 1986; Medaris et al., 2003). Structural observations have constrained the timing (Holm et al., 1998; Romano et al., 2000) and style of deformation (Dalziel and Dott, 1970; Dalziel and Stirewalt, 1975; Cambray, 1987; Czeck and Ormand, 2007; Marshak et al., 2016), as well as the degree of strain (Jank and Cambray, 1986; Craddock and McKiernan, 2007) in the foreland region of the Mazatzal Orogeny in the central United States. The Baraboo Quartzite of the Baraboo Ranges, Wisconsin, has also played an important role in the history of geology and the development of the field of structural geology. Fundamental cleavage-bedding relations during folding were first worked out in the Baraboo Quartzite around the turn of the 20th century (e.g. Van Hise, 1893), and the Baraboo Quartzite remains one of the most common field trip destinations for undergraduates in the upper Midwest of the USA (e.g. Medaris et al., 2011; Davis, 2016).

Despite the attention the Baraboo interval rocks have received, details about their regional correlation, stratigraphy, and deformational history remain uncertain. In the Baraboo Ranges, Wisconsin (Fig. 1), Baraboo interval metasedimentary units include the Baraboo Quartzite, Seeley Slate, and Freedom Formation. Van Hise and Leith (1911) proposed additional units stratigraphically overlie the Freedom Formation, based on their observation of exploration drill core and records. A. Leith (1935) named these units the Dake Quartzite and the Rowley Creek Slate. After 1935 geologists could not confirm the existence of this