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Mesoproterozoic syntectonic garnet within Belt Supergroup metamorphic tectonites: Evidence of Grenville-age metamorphism and deformation along northwest Laurentia

Timothy O. Nesheim [a,b,c,*], Jeffrey D. Vervoort [a], William C. McClelland [b], Jane A. Gilotti [b], Helen M. Lang [d]

[a] School of Earth and Environmental Sciences, Washington State University, Pullman, WA 99164, United States
[b] Department of Geoscience, University of Iowa, Iowa City, IA 52242, United States
[c] North Dakota Geological Survey, Bismarck, ND 58505, United States
[d] Department of Geology and Geography, West Virginia University, Morgantown, WV 26506-6300, United States

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ABSTRACT

Northern Idaho contains Belt-Purcell Supergroup equivalent metamorphic tectonites that underwent two regional deformational and metamorphic events during the Mesoproterozoic. Garnet-bearing pelitic schists from the Snow Peak area of northern Idaho yield Lu–Hf garnet-whole rock ages of 1085 ± 2 Ma, 1198 ± 79 Ma, 1207 ± 8 Ma, 1255 ± 28 Ma, and 1314 ± 2 Ma. Garnet from one sample, collected from the Clarkia area, was micro-drilled to obtain separate core and rim material that produced ages of 1347 ± 10 Ma and 1102 ± 47 Ma. The core versus rim ages from the micro-drilled sample along with the textural and spatial evidence of the other Lu–Hf garnet ages indicate two metamorphic garnet growth events at ~1330 Ma (M1) and ~1080 Ma (M2) with the intermediate ages representing mixed ages. Some garnet likely nucleated and grew M1 garnet cores that were later overgrown by younger M2 garnet rims. Most garnet throughout the Clarkia and Snow Peak areas are syntectonic with a regional penetrative deformational fabric, preserved as a strong preferred orientation of metamorphic matrix minerals (e.g., muscovite and biotite). The syntectonic garnets are interpreted to represent one regional, coeval metamorphic and deformation event at ~1080 Ma, which overlaps in time with the Grenville Orogeny. The older ~1330 Ma ages may represent an extension of the East Kootenay Orogeny described in western Canada. These deformational and metamorphic events indicate that western Laurentia (North America) was tectonically active in the Mesoproterozoic and during the assembly of the supercontinent Rodinia.

1. Introduction

During the Mesoproterozoic, between 1.3 and 1.0 Ga, many of the Earth's continents are thought to have merged together into a supercontinent called Rodinia. Geologists have used documented 1.3–1.0 Ga orogenic belts (e.g., the 1090–980 Ma Grenville Orogeny in North America, Rivers, 2008), paleomagnetic data, and various geologic units as piercing points to correlate across cratons in order to reconstruct Rodinia (Brookefield, 1993; Dalziel, 1991; Hoffman, 1991; Karlstrom et al., 2001; Li et al., 2008b; Moores, 1991; Sears and Price, 2003). A major difference between these reconstructions has been the western border of Laurentia. Laurentia is commonly placed in the center of Rodinia with its western border juxtaposed against Australia (Brookefield, 1993; Karlstrom et al., 2001), East Antarctica (Hoffman, 1991), Siberia (Sears, 2007; Sears and Price, 1978, 2003), Australia and East Antarctica (Dalziel, 1991; Goodge et al., 2008), or Australia–East Antarctica–North China (Li et al., 2008b). A major consensus on this topic has yet to be reached. One important geological unit located along western Laurentia, which may help to delineate the competing ideas, is the Belt-Purcell Supergroup.

The Belt-Purcell Supergroup, hereafter referred to as the Belt Supergroup, is a large ~1.4 Ga sedimentary sequence present along the northwest margin of Laurentia (Link et al., 1993; Winston, 1978). The Belt Supergroup has been studied in part to determine the matching craton that bordered western Laurentia at the time of its deposition. Researchers have attempted to correlate the Belt Supergroup with sedimentary sequences of similar age from other cratons (e.g., Udzha Basin of Siberia, Sears et al., 2004), and have used detrital zircon signatures to suggest potential provenances for Belt Supergroup sediments (e.g., the Gawler Craton of Australia, Ross and Villenueve, 2003). One feature present in the Belt Supergroup that has yet to be tapped for information relevant to reconstructions of Rodinia is the evidence of 1.3–1.0 Ga metamorphism.

Various Mesoproterozoic ages have been reported throughout the Belt Supergroup (Anderson and Davis, 1995; Chase et al., 1971; Doughty and Chamberlain, 2004; Evans and Fischer, 1986; Evans and Zartman, 1990; Kulp and Eckelmann, 1957; Lydon, 2000; Reid et al., 1981; Ryan and Blenkinsop, 1971), including ~1.1 Ga Lu–Hf garnet-whole rock ages (Sha et al., 2004; Vervoort et al., 2005; Zirakparvar et

* Corresponding author at: North Dakota Geological Survey, 600 East Boulevard Avenue, Bismarck, ND 58505, United States. Tel.: +1 701 328 8000; fax: +1 701 328 8010.
E-mail address: tonesheim@nd.gov (T.O. Nesheim).

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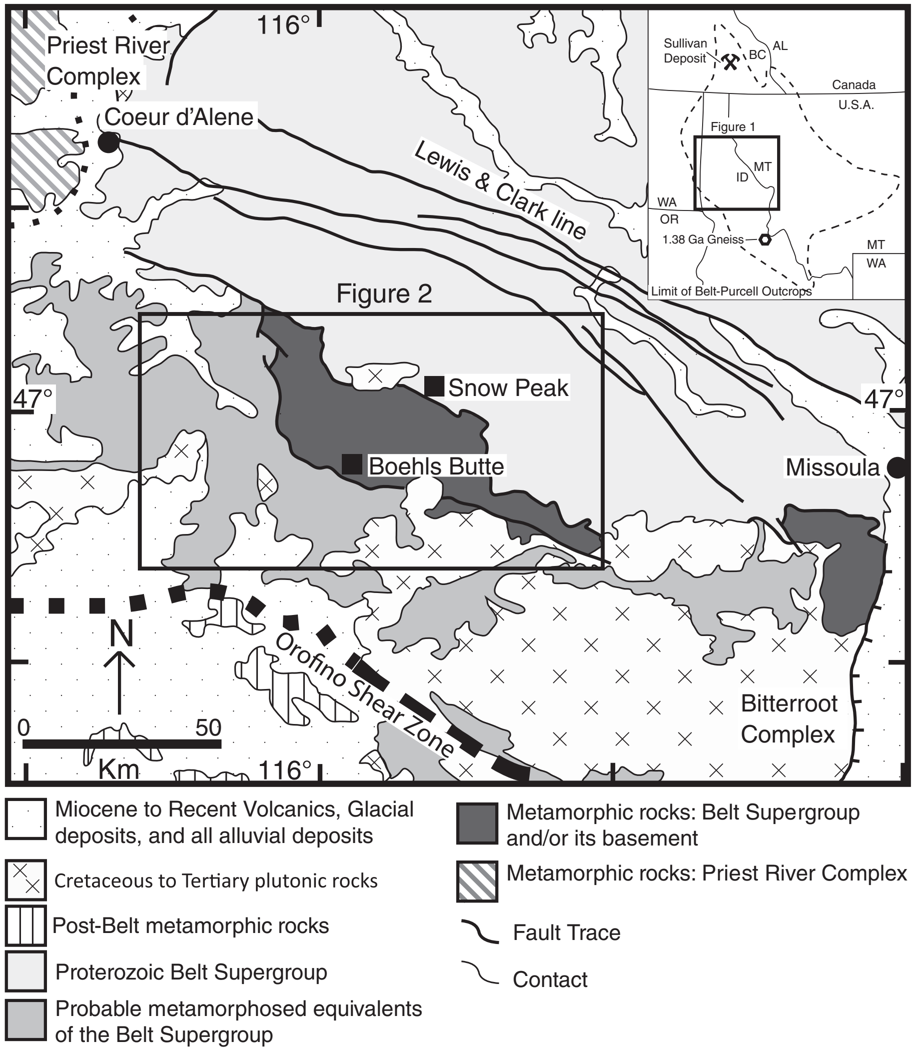

Fig. 1. Geologic map of northern Idaho, eastern Washington, and western Montana. The geology is modified after Lewis (1995) and McClelland and Oldow (2004). The "Limit of Belt-Purcell Supergroup outcrops" is borrowed from Lydon (2000). The age and location of the 1.38 Ga Augen Gneiss is from Evans and Fischer (1986) and Evans and Zartman (1990). The box shows the study area in Fig. 2.

al., 2010). The published Lu–Hf ages, ranging from 1151 Ma to 1006 Ma, are thought to represent a regional Mesoproterozoic metamorphic event, but the details of this metamorphism, and its regional tectonic framework, have not yet been thoroughly examined. Doughty and Chamberlain (2004) argue for a static thermal event, while Zirakparvar et al. (2010) call for a regional deformational (orogenic) event, which would overlap in time with the Grenville Orogeny. In this paper, we correlate new Lu–Hf garnet-whole rock ages with regional penetrative deformational fabrics in an effort to examine the extent and timing of Proterozoic deformation and metamorphism within the Belt Supergroup of northern Idaho.

2. Background

2.1. Geologic history

The Belt Supergroup is an approximately 15–20 km thick sedimentary sequence that extends across eastern Washington, northern Idaho, western Montana, and southern British Columbia (Fig. 1) (Link et al., 1993; Winston, 1978). It is widely thought that sediments of the Belt Supergroup were deposited semi-continuously between 1.47 and 1.40 Ga (Evans et al., 2000) in a large intra-continental extensional basin (Ross and Villenueve, 2003). Mafic sills dated at ~1468 Ma intrude the lower Belt formations (Anderson and Davis, 1995) and provide a minimum age for the beginning of deposition. Most outcrops and samples examined by this study correlate with the Wallace Formation, which lies in the middle of the Belt Supergroup. The Wallace Formation is thought to have been deposited in a lacustrine setting and is dominantly composed of siliciclastic material with some carbonate-rich layers (Winston, 2007).

Underlying the Belt Supergroup is ~2.7–1.6 Ga crystalline basement, which is thought to consist primarily of juvenile arc-like terranes collectively referred to as the Selway terrane (Foster et al., 2006). Newly revealed ~2.7–1.8 Ga basement, consisting of metasedimentary and meta-igneous rocks (Brewer et al., 2008), is exposed across the center of the study area (Figs. 1 and 2). Another Archean–Proterozic feature, the Priest River Complex, is located along the northern Idaho-eastern Washington border (Fig. 1) and includes

Fig. 2. Simplified geologic map of field area with locations of 1.35–1.06 Ga garnet from Zirakparvar et al. (2010), yellow stars, and this study, green stars. Geology is modified after Lewis et al. (2000, 2005, 2007), Wallace Quadrangle (Lewis, unpublished), and Lonn and McFadden (1999); the red line is the regional M2 Garnet-in isograd after Lewis et al. (2000, 2005, 2007) and Wallace Quadrangle (Lewis, unpublished). The areas of Figs. 6 and 11 are outlined and labeled.