The Early Paleozoic Windermere High, southern Canadian Cordillera: Implications for the continuity of the Lower Paleozoic tectonostratigraphic succession and for Early Paleozoic Tectonics

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Introduction

Uppermost Neoproterozoic and Lower Paleozoic strata can be confidently correlated from wells in the Plains, through outcrops in the Rockies, and across the Purcell Mountains to the Selkirk Mountains (Fig. 1; Simony et al., 2020). These correlations present a coherent view of deposition at the Early Paleozoic Laurentian passive margin, and firmly establish that all of the strata are of North American affinity. This observation contradicts the proposals of tectonic hypotheses such as the Cordilleria model (Chamberlain and Lambert, 1985), the SAYBIA model (Johnston, 2008; Chen et al., 2019), and the Rubia ribbon continent model (Hildebrand, 2013) that there is a major tectonic suture present within the Rockies that separates North American rocks from allochthonous ‘ribbon continent’ rocks.

The Uppermost Neoproterozoic and Lower Paleozoic sequence in the eastern Purcell Mountains and western Rocky Mountains in SE British Columbia at approximately 50° 30’ N latitude is anomalously thin compared to strata to the east and west, and locally absent, due to the presence of a paleo-high called the Windermere High (Fig. 1). The Windermere High and other Early Paleozoic highs such as the Dogtooth High (Kubli and Simony, 1992) and the Kinbasket High (Hrudey, 2002) are interpreted to have formed during Early Paleozoic extensional events at the outer, western region of the ancient Laurentian passive continental margin.

Distribution and Correlations of Uppermost Neoproterozoic and Lower Paleozoic Strata

In the Plains, Foothills, and Front and Eastern Main Ranges of the Rockies the Lower Paleozoic sequence comprises a basal sandstone succession (Gog Group and Basal Sandstone Unit) and overlying shallow water, dominantly carbonate strata. Strata as young as the Ordovician-Silurian Beaverfoot Formation are preserved locally in the Main Ranges below the sub-Devonian unconformity. Further east, in the Front Ranges and the Plains, the upper portions of the Lower Paleozoic succession have been removed by erosion below the sub-Devonian unconformity due to uplift of the Western Alberta Ridge.

A facies change, initially recognized by McConnell (1887), is present at a fault-controlled north-northwest-trending syndepositional high called the Kicking Horse Rim, located at the boundary between the Eastern and Western MainRanges (Aitken, 1971). Most of the shallow water Cambrian and Ordovician carbonate strata change to the southwest across this trend into ‘deeper water’ mudstone, argillaceous limestone, and limestone that were deposited within the White River Trough as turbidites, debris flows, and hemipelagic deposits in the Chancellor Group, McKay Group, and Glenogle Formation. (Fig.1; Aitken, 1971; Cook, 1975; Stewart,
1991; Collom et al., 2009). Two carbonate successions, the Upper Cambrian Lyell – Ottertail – Jubilee Formation and the Ordovician – Silurian Beaverfoot Formation, do not change facies across the Kicking Horse Rim and continue westward as shallow water carbonates. Although the facies transition is complicated by Cambrian gravity-glide megatrunccation surfaces (Stewart, 1991), lateral continuity can be directly observed across the facies transition for some Middle Cambrian units (see descriptions and photographs in Cook, 1975; Stewart, 1991; Aitken, 1997; Collom et al, 2009; Johnston et al., 2009). None of the published geological studies in this area have recognized any relationships that indicate that a major suture is present, as hypothesized in the ribbon continent hypotheses (Johnston, 2008; Hildebrand, 2013; Chen et al., 2019).

Lower Paleozoic strata thicken to the west across the Kicking Horse Rim facies change and reach thicknesses of 7500 m or more within the White River Trough (Fig. 1). The Lower Paleozoic succession thins systematically southwestward, however, across the Western Rockies and the eastern Purcell Mountains due to periods of reduced subsidence and uplift on the Windermere High. At the culmination of the Windermere High, at Delphine Creek, the entire Lower Paleozoic section is missing, and Devonian strata overlie anomalously thin Neoproterozoic Windermere Supergroup strata.

Southwest of the Windermere High, across the Mount Forster Thrust in the western Purcell and Selkirk Mountains, significant thicknesses of Lower Cambrian and overlying Lardeau Group metamorphosed and highly deformed clastics and volcanics are present (Fig. 1; Fyles and Eastwood, 1964; Kraft, 2013). There are few age data for Lardeau Group strata, but the succession is overlain by the Upper Devonian Mount Sproat assemblage (Thompson et al., 2006; Kraft, 2013); this constrains the age of the underlying Lardeau Group strata to be Late Devonian or older. Kraft (2013) speculated that the upper unit of the Lardeau Group, the Broadview Formation sandstone and conglomerate, may correlate with the Middle Devonian Mount Forster Formation of the Purcell Mountains, and this suggestion has been followed in Fig.1.

Although the details of western boundary of the Windermere High are obscured by the Mesozoic Mount Forster Thrust fault, there presumably were one or more significant southwest-side-down extensional faults that bounded the high on the southwest. Several stratigraphic units, including multiple members of the Neoproterozoic(?) Mount Nelson Formation, and the Toby Formation and Horsethief Creek Group of the Neoproterozoic Windermere Supergroup, as well as Lower Cambrian strata, can be confidently recognized in both the footwall and the hanging wall of the fault.

Additional highs were present during the Early Cambrian to the north of the Windermere High; these include the Dogtooth High (Kubli and Simony, 1992) and the Kinbasket High (Hrudey, 2002). In these regions, strata younger than Early Cambrian are not present, and thus the post-Early Cambrian record of activity on these highs is not preserved.

**Extensional Tectonics**
Evidence for Late Neoproterozoic and Early Paleozoic extensional tectonic activity in the region includes the significant extensional faults inferred to separate the crest of the Windermere High from the subsiding Lardeau Trough to the west (Fig. 1) as well as the extensional faults at the
Kicking Horse Rim (Aitken, 1971; Collom et al., 2009; Johnston et al., 2009). Additional evidence for extension includes the local presence of mafic volcanic and volcanogenic rocks within Cambrian strata within the White River Trough (Norford and Cecile, 1994; Larson and Price, 2006) and mafic volcanics within the Lower Paleozoic Lardeau Group in the Lardeau Trough (Fyles and Eastwood, 1964; Kraft, 2013). Intrusive alkaline, ultrabasic diatreme breccia pipes and dikes were intruded locally in the White River Trough during the Late Ordovician and between the Early Silurian and Middle Devonian (Leech, 1958; Helmstaedt et al., 1988; Pell, 1994). The Windermere High is interpreted to have formed as a rift shoulder related to the Early Paleozoic extension within the Lardeau Trough to the west.

References


Fig. 1: Stratigraphic cross-section from the Selkirk Mountains to the Plains. Datum is the base of the Devonian. Sources of data: Henderson, 1954; Leech, 1958; Fyles and Eastwood, 1962; Reesor, 1973; Alkhen, 1963; Cook, 1975; Norford, 1981; Stewart, 1991; Root, 2001; Colom et al., 2009; Kraft, 2013.