Ashman Ridge Section revisited: New insights for the evolution of the Bowser Basin, Northwestern British Columbia

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Introduction

The Bowser Basin is a large sedimentary basin deposited above basement of the Stikine Terrane in the Intermontane Belt of northwestern British Columbia (Fig. 1). It was the site of deposition of a large volume of siliciclastic sediments during Middle Jurassic through Early Cretaceous time. Approximately 6 km of marine to non-marine sediments, mainly assigned to the Bowser Lake Group, were deposited onto the Early to Middle Jurassic volcano-sedimentary assemblage of the Hazelton Group (Ritketts *et al*., 1992; Evenchick and Thorkelson, 2005). The boundary between these units marks a major change in depositional style, from a volcanic arc setting to a subsiding sedimentary basin. The transition zone hosts significant mineralization (*e.g.* Eskay Creek Au-Ag deposit; Anderson, 1993; Barrett and Sherlock, 1996; Roth *et al*., 1999) as well as dark organic shales with significant potential as a petroleum source rock; Ferri *et al*., 2004; Ferri and Boddy 2005); a clear understanding of the nature of this stratigraphic transition at basin scale could provide new insights for both mineral and hydrocarbon exploration.

The aim of this study is to provide new detailed stratigraphic observations of the Ashman Ridge section (Fig. 2), which exhibits continuous exposure across the Hazelton Group - Bowser Lake Group transition. The section was originally described as a part of a project involving regional stratigraphic mapping of north-central British Columbia by Tipper and Richards (1976), who defined the Ashman Formation of the Bowser Lake Group and proposed Ashman Ridge as the type section. Stratigraphically lower units of the Hazelton Group are also well exposed along the section and provide a complete record of the change in depositional environment.

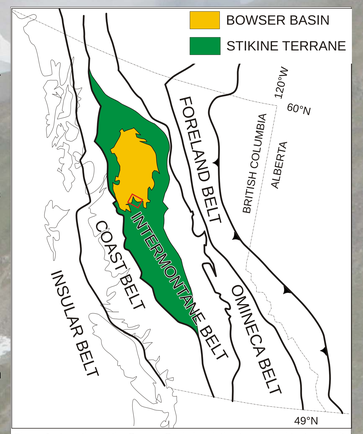

Figure 1 - Location of the Bowser Basin in relation to principal tectonic belts of the Canadian Cordillera. Red square represents the outline of Figure 2.

Lithostratigraphic units of the Ashman Ridge Section

The basal unit observed at Ashman Ridge consists of amygdaloidal andesitic to dacitic flows and associated pyroclastic rocks of the Hazelton Group. The presence of highly indurated ignimbrite containing flattened pumice suggests that these volcanic rocks were mostly deposited in a subaerial environment. The uppermost dominantly volcanogenic unit of the section consists of maroon to bright red fine-grained crystal-lithic tuff (unit A in Fig. 3). This unit was classified by Tipper and Richards (1976) as part of the Nilkitkwa Formation. Its age was estimated to be Middle Toarcian or younger based on paleontological control in underlying and overlying units. It comprises well bedded welded ash flow tuffs, poorly sorted rubbly lapilli tuff, and lahars. Rounded volcanic bombs up to 30 cm in diameter are common in a very fine-grained matrix. Deposition of the red tuff unit constitutes the last major episode of volcanic activity related to the Hazelton arc in the area before widespread sedimentation of the Smithers Formation was initiated.

Establishment of a subsiding sedimentary basin on the Hazelton arc occured around the Middle Toarcian and is recorded by the deposition of the Smithers Formation above a regional unconformity. This unit is characterized by a mixture of fossiliferous light grey-brown sandstone and tuffaceous siltstone (unit B in Fig. 3). It contains abundant marine fossils including belemnites, gastropods, corals, ammonoids and a wide variety of ornate bivalves such as *Trigonia* (Fig. 4). Bioturbation is omnipresent and the occurrence of wave-generated sedimentary structures suggest that the unit was deposited in relatively shallow marine conditions. Fossiliferous calcareous sandstones of the Smithers Formation are conformably overlain by a unit of thinly bedded blocky siliceous mudstone with recessive pale orange-weathered tuff beds (unit C in Fig. 3). This unit contrasts with the underlying sandstones; it lacks abundant bivalves, shows only sparse bioturbation and is significantly finer-grained. Well preserved ammonites including *Kepplerites* sp. and *Cobbanites* sp. (Fig. 5) were collected approximately 66.5 m below the top of the thinly bedded unit. The fine grain-size, laterally continuous bedding and lack of current-generated structures indicate that this unit accumulated mostly from suspension.

The siliceous fine-grained succession is overlain with a sharp but apparently conformable boundary (Fig. 6) by brown and white-weathering arkosic sandstone with thick limy concretions, marking the base of unit D (Fig. 3). The medium-grained sandstones contain abundant mud rip-up clasts at the bases of the 40 to 70 cm thick beds. Hummocky-cross stratification, trough cross-bedding and climbing ripples are common sedimentary structures in this unit. The depositional environment for this sand-rich unit is interpreted to be one of high energy, contrasting with conditions that prevailed during the deposition of the underlying belemnite-rich siliceous argillites of unit C.

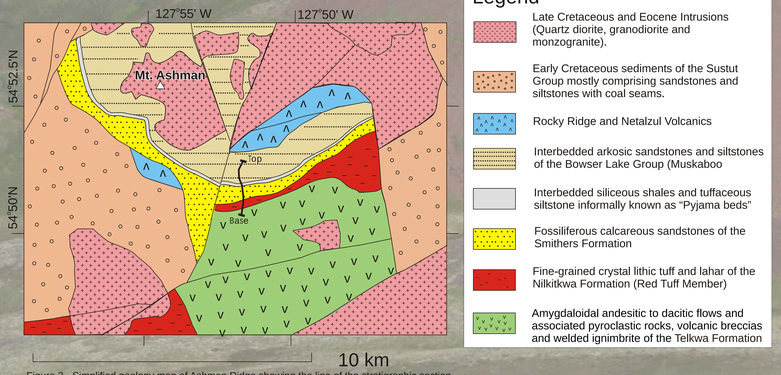

Figure 2 - Simplified geology map of Ashman Ridge showing the line of the stratigraphic section.

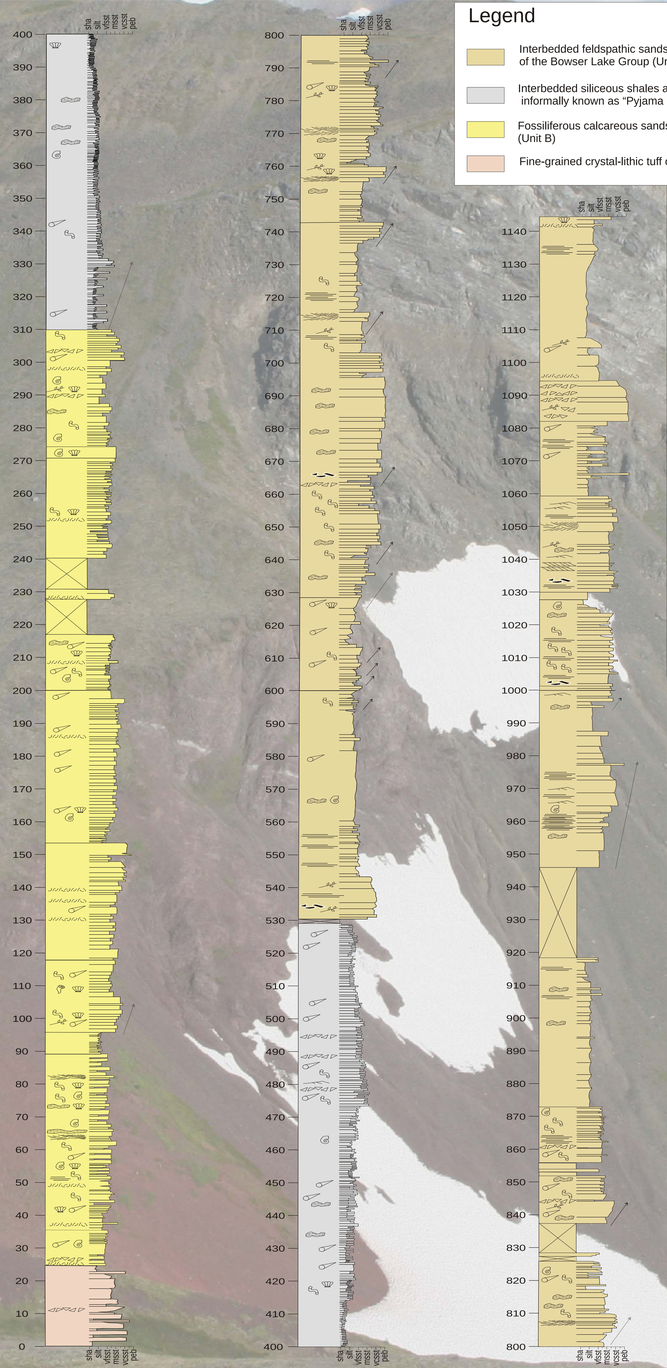

Figure 3 - Detailed stratigraphic section showing the four mappable lithostratigraphic units observed at Ashman Ridge. Measurements of section in metres.

Figure 4 - *Trigonia* bivalve of the Smithers Formation indicating shallow marine conditions. Sample was taken at 55 m of the measured section.

Figure 5 - Well preserved ammonites *Kepplerites* sp. and *Cobbanites* sp. collected at 462 m in the measured section. These fossils indicate a Lower Callovian age.

Figure 6 - Blocky siliceous mudstones and pale orange tuffaceous beds (pyjama bed) conformably overlain by arkosic sandstones of the Bowser Lake Group.

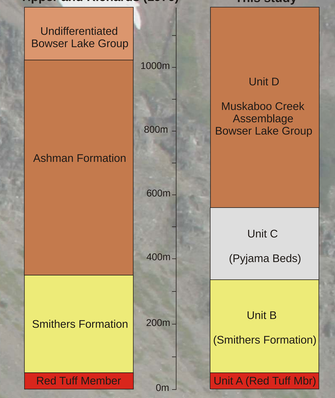

Figure 7 - Stratigraphic correlations between the detailed section of this study and Tipper and Richards' (1976) original type section of the Ashman Formation.

Conclusion

Tipper and Richards (1976) suggested Ashman Ridge as the type section for the Ashman Formation of the Bowser Lake Group. Based on our correlations made between units mapped at Ashman Ridge and equivalent stratigraphic sections exposed further north in the Bowser Basin (Thomson *et al.,* 1986; Anderson and Thorkelson, 1990; Greig, 1991; Waldron *et al.,* 2006; Gagnon *et al.,* 2007), we suggest a different subdivision (Fig. 7). Unit B is a clearly mappable interval of bioturbated fossiliferous sandstone that corresponds closely, in lithological character, to Tipper and Richards' (1976) definition of the Smithers Formation. Therefore, the top of the Smithers Formation should be set at the top of the uppermost heavily bioturbated calcareous sandstone bed observed at 310 m in the measured section (Fig. 3).

Following the same logic, the next important lithological boundary occurs at 531 m where interbedded siliceous mudstones and tuffs of unit C are overlain by laminated medium to very coarse arkosic sandstone beds of unit D with abundant mud rip-up clasts and wood fragments. This marks a significant change in depositional environment within the basin. Overlying non-silicified clastic sediments of unit D, assigned to the Ashman Formation by Tipper and Richards, bear a close field resemblance to widespread shallow-marine units of the Bowser Lake Group assigned to the Muskaboo Creek assemblage of Evenchick *et al.* (2001). The upper boundary of this facies is not seen at Ashman Ridge, and we see no justification for placing an upper boundary at the top of Tipper and Richards' (1976) section. Therefore, we proposed that the name Ashman Formation be abandoned. It does not represent a clearly defined mappable unit and is inconsistent with stratigraphic nomenclature defined in other areas of the Bowser Basin. Furthermore, our observations confirm the presence of a mappable "pyjama beds" unit conformably underlying sediments of the Bowser Lake Group at the basin scale. This has important implications for both petroleum and mineral exploration, as equivalent stratigraphic units in the northern part of the Bowser Basin host volcanogenic massive sulphide mineralization and have proven petroleum source rock properties.

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