Boundary Project: Reassessment of Paleozoic Rock Units of the Greenwood Area (NTS 82E/02), Southern British Columbia

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KEYWORDS: Greenwood, Quesnellia, Knob Hill complex, Attwood Formation, Lexington porphyry

INTRODUCTION

The Boundary Project has been initiated with the purpose of better characterizing the lithological and geochemical variations within and between the various Paleozoic sequences in the southern Okanagan region along the United States border. These occur within the Quesnel Terrane, which is dominated by such Paleozoic mafic volcanic and pelitic rocks, unconformably overlain by Triassic and Jurassic volcanic and sedimentary rocks. In the Boundary District, such sequences include the Knob Hill Complex, Attwood Formation, Kobau Group and Anarchist Schist. These are exposed between down-faulted blocks of Tertiary volcanic and sedimentary cover preserved in structural keels between gneissic domes (Fig. 1). In 2005, fieldwork was concentrated in the Greenwood – Rock Creek area (NTS 082E/02). In future years, fieldwork will progress into the Osoyoos (NTS 082E/03) and Keremeos (NTS 082E/04) map sheets.

The Greenwood map sheet straddles Highway 3 between Osoyoos and Grand Forks. Five weeks of fieldwork in 2005 were restricted to areas immediately around and east of Greenwood, and to the area between Midway and Rock Creek (see Fig. 7 for locations). This includes most of the area mapped by Fyles (1989, 1990), upon which this study builds. Fieldwork was focused on,

- field checking previous mapping in order to produce a new compilation map for the Greenwood sheet (Massey, work in progress);
- collecting geochemical samples from volcanic rocks in the Knob Hill Complex and Attwood Formation;
- identifying and collecting suitable materials for paleontological or geochronological age determinations of the Paleozoic sequences; and
- investigating the reported occurrence of felsic volcanic rocks within the 'Lexington porphyry'.

PREVIOUS WORK

The Greenwood – Rock Creek area has a mining history dating from the first discoveries of placer gold in the 1860s and lode deposits in the 1880s. The first geological report was that of Bauerman (1885), prepared as part of the Boundary Commission Expedition of 1859–1861. Regional mapping has been undertaken by Brock (1902, 1903, 1905a, b), Daly (1912), Little (1957, 1983), Monger (1968), Church (1986), Templeman-Kluit (1989a, b) and Fyles (1990). Detailed mapping around individual mines and mining camps includes work by LeRoy (1912, 1913), McNaughton (1945), Seraphim (1956), Carswell (1957), Church (1970) and Nixon (2002).

PALEOZOIC STRATIGRAPHY OF THE GREENWOOD – ROCK CREEK AREA

Knob Hill Complex

The Knob Hill Complex dominates the Quesnellia Paleozoic rocks exposed in the Greenwood map sheet. Called the 'Knob Hill Group' by previous workers, the name is changed here to Knob Hill Complex, in line with modern accepted stratigraphic nomenclature, to reflect the inclusion of intrusive units with the layered rocks (Murphy and Salvador, 1999).

The complex is composed of chert, argillite, basalt, gabbro and serpentinite that together constitute a disrupted ophiolite (Little, 1983; Dostal *et al.*, 2001). It was included in the Okanagan subterrane of Quesnellia by Monger *et al.* (1991), along with other assemblages of oceanic affinity such as the Kobau and Old Tom – Shoemaker Groups. The stratigraphic thickness of the Knob Hill Complex is uncertain and difficult to estimate due to structural disruption. Little (1983) suggested "a minimum of a few thousands of metres", whereas Fyles (1990, 1995) estimated the complex to be more than 5 km thick.

The age of the Knob Hill Complex is still poorly determined. A Carboniferous to Permian age was assigned by Little based on a single macrofossil locality (Little, 1983, page 12, locality F7). However, this same limestone bed has yielded conodonts of Late Devonian (Frasnian) age (Orchard, 1993). Church (1986) reported a K-Ar whole rock age of 258 ±10 Ma (Permian) for uralitized gabbro from the Winnipeg mine. However, the reliability of such K-Ar whole rock ages is very suspect, and it is doubtful that this is recording a crystallization age. Refinement of the age of the complex awaits further paleontological and geochronological determinations.

Seven map units are recognized within the Knob Hill Complex in the Greenwood map sheet. Stratigraphic relationships between map units are not always clear. However, in the area north of Rock Creek, gabbro and serpentinite pass northward, and probably upward, into greenstone,

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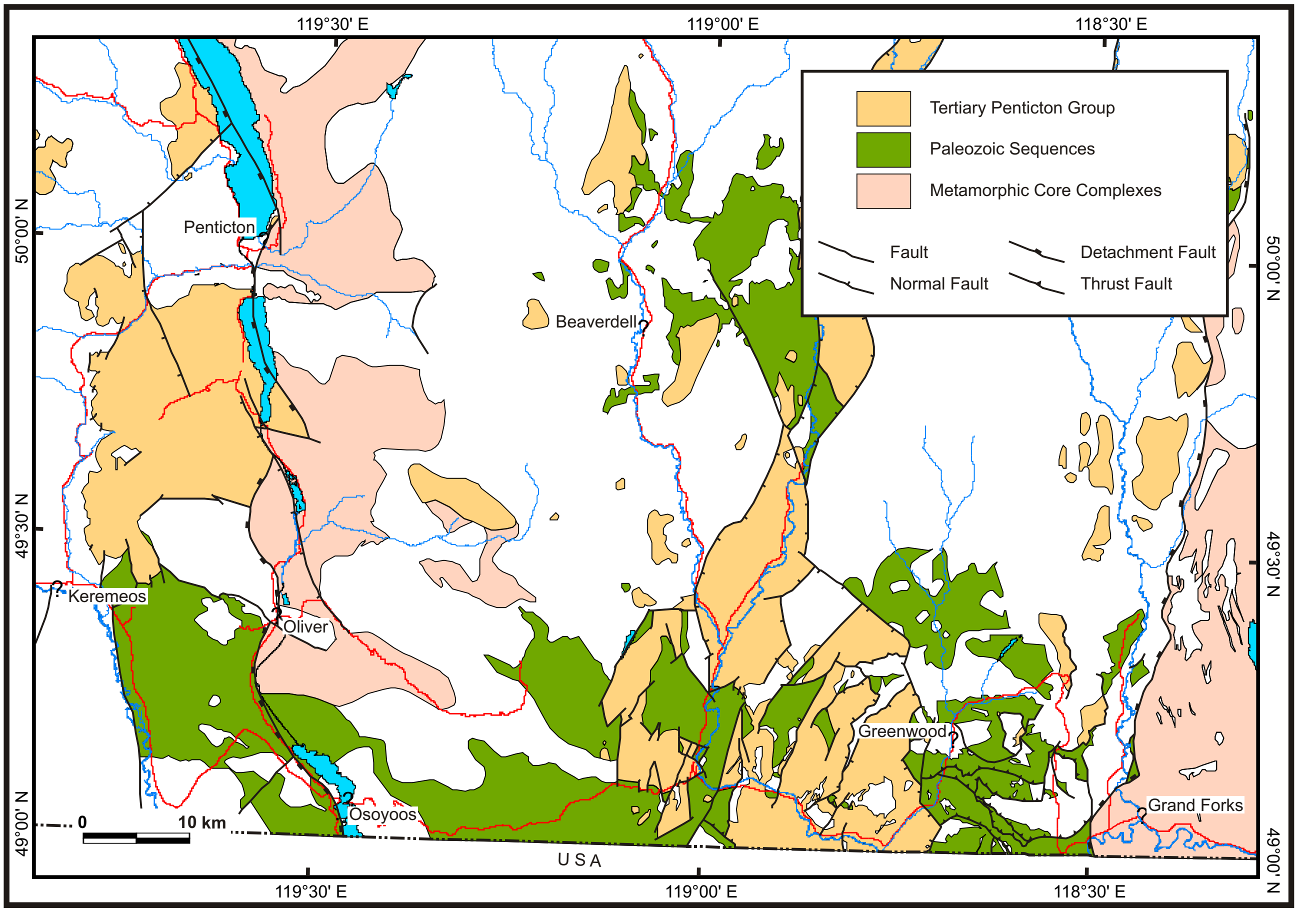

Figure 1. Distribution of Paleozoic Quesnellian rock suites in the Boundary District (south-central part of NTS 082E), amended from Massey *et al.* (2005).

mixed greenstone and chert, and finally chert and argillite. In the Greenwood area, Fyles (1990) suggested that the lower part of the Knob Hill Complex consisted of a highly variable mix of chert, argillite, conglomerate and breccia interfingering with greenstone flows. The upper part of the complex is mainly chert and greenstone. Due to the limited fieldwork undertaken in the area by the author, the following descriptions of the units draw heavily upon previous observations by Church (1986) and Fyles (1990).

GREENSTONE UNIT

The basaltic greenstone is mostly flows with minor breccia, agglomerate and tuffaceous sandstone. Chert, cherty argillite, jasper and rare limestone may occur between flows. Most flows are grey to green, massive and aphanitic. Chlorite, calcite and epidote are common alteration minerals in veins, fractures and within the rock. Pillow structures are rare, though they have been inferred by previous mappers (Fyles, 1990). Geochemically, the flows of the greenstone unit are oceanic basalt (Dostal *et al.*, 2001) and may have formed at a mid-ocean ridge or in a back-arc basin.

Medium-grained diabase to microgabbro bodies also occur within the greenstone unit. In general, these are featureless rock units in outcrop. However, outcrops along the power line adjacent to the Winnipeg mine show well-developed chilled margins, suggesting that they may be part of an unmapped sheeted dike complex (Fig. 2a). Dikes are also seen intruding the nearby gabbro (Fig. 2c).

CHERT-ARGILLITE UNIT

Sedimentary rocks in the Knob Hill Complex are typically fine grained, mainly grey to white chert interbedded with grey to black argillite and minor greenstone. The chert is highly fractured and jointed, tends to be massive to thickly bedded and only rarely shows ribbon structures. Radiolarians are reported in thin section (Church, 1986) but are rarely seen in hand specimen. Variable recrystallization of the chert produces a fine to medium-grained saccharoidal texture. Argillite is rarely bedded and may show gradational contacts with chert horizons. Thin white crystalline limestone forms occasional outcrops.

MIXED GREENSTONE AND CHERT UNIT

In the western part of the map sheet, between upper Nicholson Creek and Kettle River, a belt of mixed greenstone and chert in roughly equal proportions forms a transition between the greenstone unit to the south and the chert-argillite unit to the north (Fig. 3). Rock types are similar to those found in the other two units.

CHERT BRECCIA

Two areas of buff to cream and grey chert breccia and pebble conglomerate were outlined by Fyles (1990). They contain angular to subrounded chert clasts similar to the

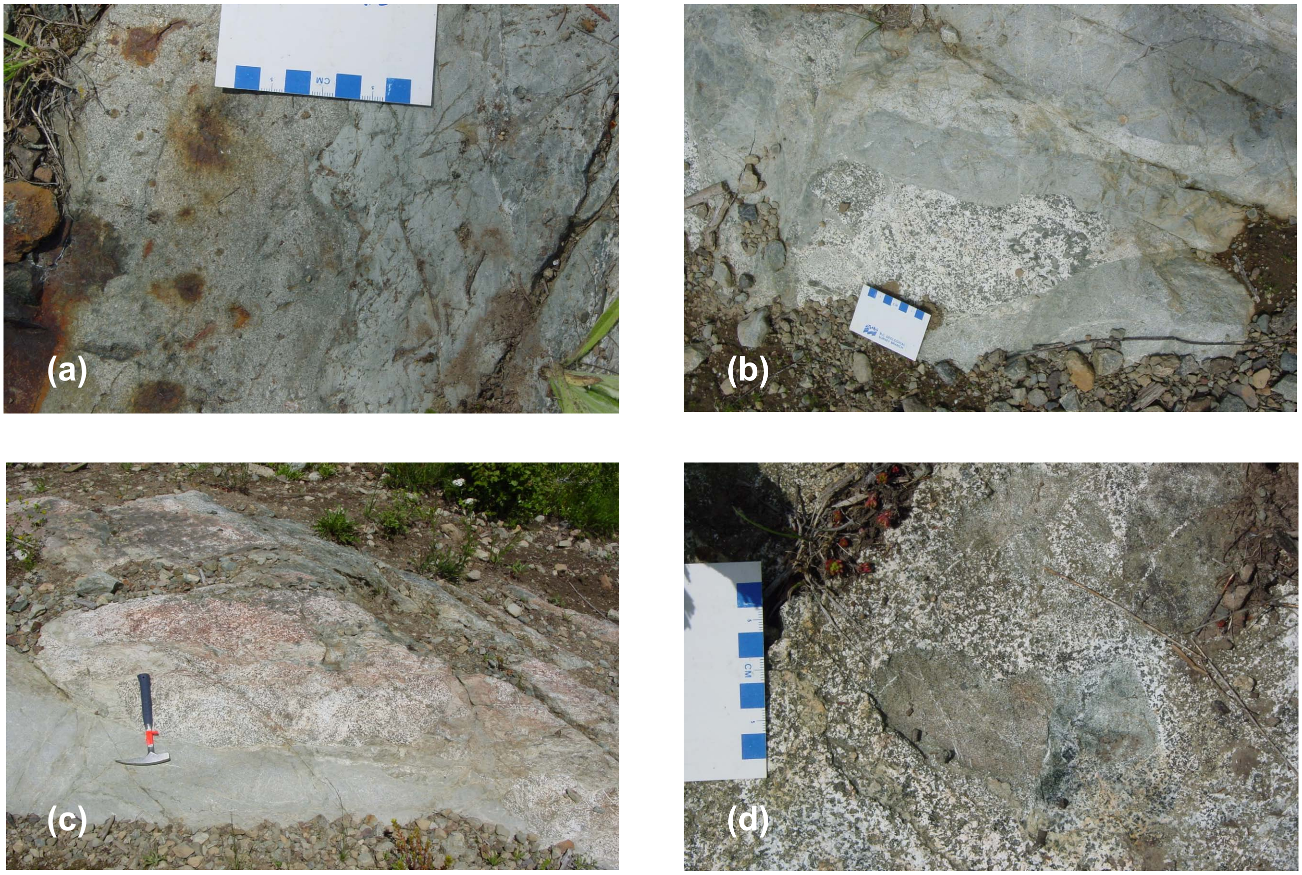

Figure 2: Diabase dikes in the Knob Hill Complex: a) chilled contact between diabase dikes (05NMA02-08; UTM Zone 11, 5436632N, 385389E, NAD83); b) gabbro screen between two diabase dikes (05NMA02-09; UTM Zone 11, 5436682N, 385375E, NAD83); c) diabase intruding gabbro body (05NMA02-09; UTM Zone 11, 5436682N, 385375E, NAD83); d) diabase inclusion within gabbro (05NMA02-10; UTM Zone 11, 5436766N, 385333E, NAD83).

chert of the chert-argillite unit. They lack the variety of other clast types, such as greenstone, serpentinite, jasper, and limestone, found in the Triassic Brooklyn Formation sharpstone conglomerate. Black siltstone and chert sandstone occur as interbedded lenses. Similar chert breccia also forms a prominent hill just south of Norwegian Creek, immediately west of the Sappho property, and is probably correlative.

GREENWOOD GABBRO

This unit was originally informally called the 'Old Diorite' by Church (1986) and renamed the 'Greenwood Gabbro' by Dostal *et al.* (2001). The latter term is preferred here as being in agreement with modern stratigraphic nomenclature.

The gabbro is composed of white plagioclase and green to black pyroxene that is extensively replaced by hornblende. Chlorite is common on fractures and in shears. The gabbro is generally massive and characteristically variable and patchy in texture, with coarse-grained gabbro phases grading into finer microgabbro or even coarser pegmatitic phases (Fig. 4). No chilled contacts are seen between phases. Light-coloured felsic veins (plagiogranite?) criss-cross some outcrops. Occasional diabase xenoliths are included in the gabbro (Fig. 2d).

Greenwood Gabbro samples are geochemically comparable to oceanic plutonic rocks (Dostal *et al.*, 2001) and are probably comagmatic with the greenstone flows.

SERPENTINITE

Serpentinite occurs dominantly as fairly continuous sheets along faults, or as irregular lenticular bodies that are commonly spatially associated with gabbro bodies. The

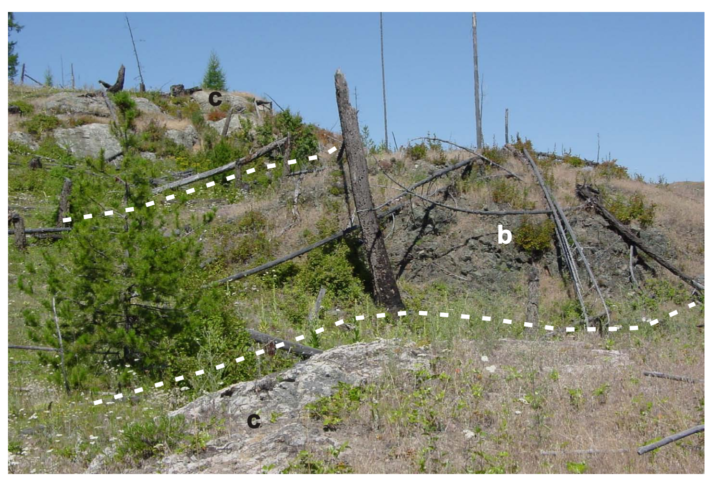

Figure 3. Interbedded chert (c) and greenstone flows (b) of the Knob Hill Complex, east side of the Kettle River valley (05NMA23-08; UTM Zone 11, 5443408N, 357292E, NAD83).

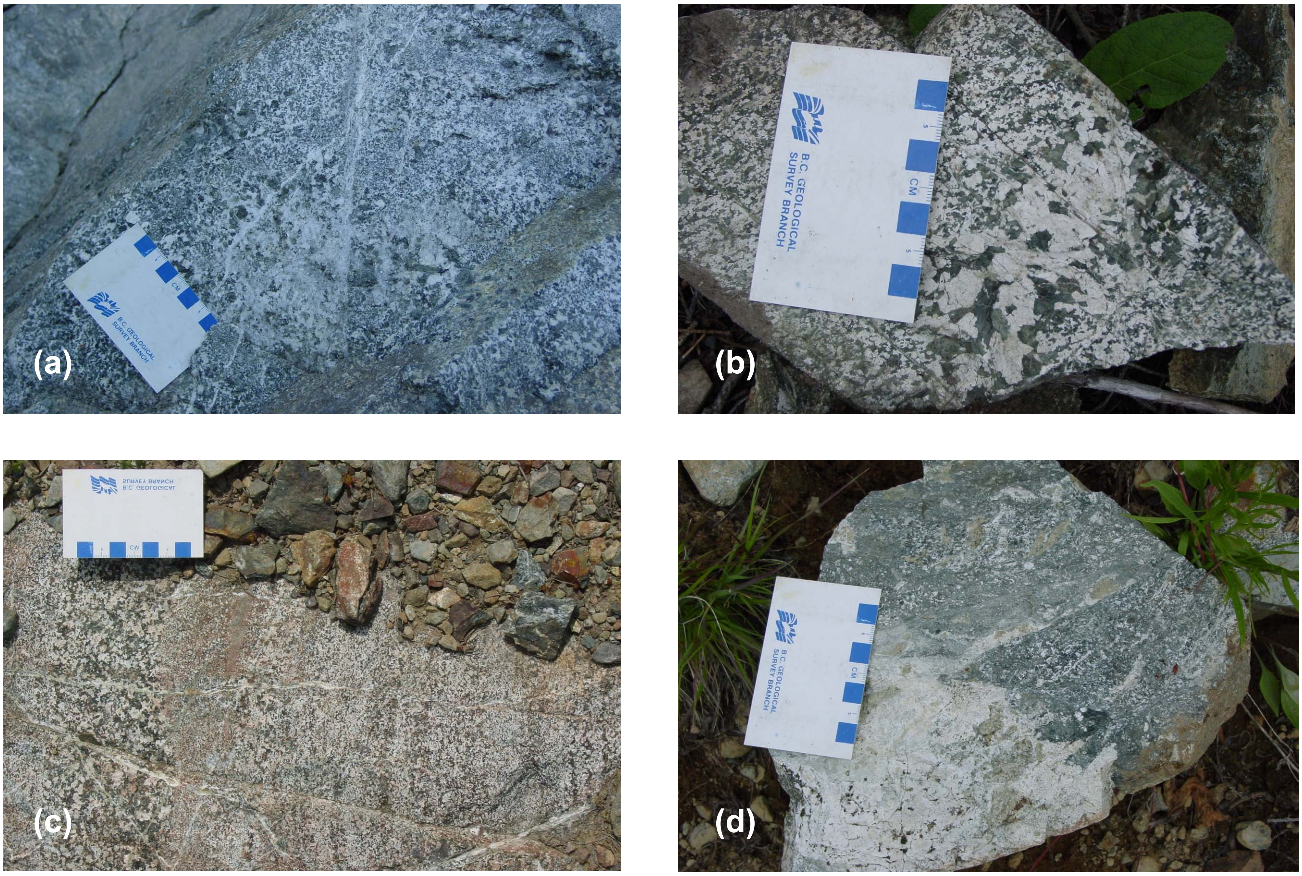

Figure 4. Greenwood Gabbro: a) typical variably textured gabbro, with white felsic vein network (05NMA21-02; UTM Zone 11, 5436561N, 353922E, NAD83); b) very coarse pegmatitic gabbro (05NMA02-03; UTM Zone 11, 5436880N, 385180E, NAD83); c) colour and grain-size layering in gabbro (05NMA02-11; UTM Zone 11, 5436808N, 385264E, NAD83); d) plagiogranite dike in variably textured gabbro (05NMA02-11; UTM Zone 11, 5436808N, 385264E, NAD83).

serpentinite is usually dark green to black and schistose to blocky, with greasy fracture coatings. Foliated serpentinite may contain boudins of blocky serpentinite. Original mineralogy is almost totally replaced by antigorite, though coarse relict pyroxene is seen in roadcuts along Highway 3 about 1.5 km south of the Phoenix Ski Hill turnoff. Talc and talc-carbonate are common in sheared margins of serpentinite bodies.

Listwanite is common in the western part of the map sheet along the Kettle River valley north of Rock Creek. This is a pale buff-white, crystalline, carbonate-rich rock that weathers to an orange-brown colour. There may be a soapy feel on some surfaces. Siliceous patches and veins weather positively and often show an apple green colour due to chlorite or mariposite(?). Late quartz veins contain minor sulphide minerals.

METAMORPHIC UNIT

Deformed and higher grade metamorphosed rocks ascribed to the Knob Hill Complex (Fig. 5) occur in three main belts. South of Rock Creek, the rocks comprise chert, quartzite, micaceous quartzite, greenstone, chlorite schist, limestone and dolomite. These are lithologically similar to chert-argillite and greenstone sequences found to the north of Rock Creek, although their structural relationship is uncertain due to lack of outcrop.

A second belt outcrops in the southeastern part of the map sheet, between Boundary Falls and Grand Forks, as a thrust slice between the Mount Wright and No 7 faults (see Fig. 7). This belt includes chlorite and chlorite-amphibole schists, quartz-biotite schist and phyllite, quartz-biotite gneiss, quartzite, chert, calcareous phyllite and crystalline limestone, minor greenstone and metagabbro.

The third belt of the metamorphic unit extends from Mount Roderick Dhu west to Windfall Creek. Metamorphic grade increases northwestward, from the greenstone and metachert found south of Jewel Lake into amphibolite, metagabbro, quartzite, micaceous quartzite, quartz-biotite schist, biotite-muscovite schist, quartz-biotite and quartz-feldspar-biotite gneiss.

Little (1983) referred to the latter two belts as a metamorphic assemblage of pre-Carboniferous (possible Proterozoic?) age. Church (1986), Fyles (1990) and this author include them in the Knob Hill Complex because of their lithological similarities to other mapped units in the Knob Hill. However, the contrast in structural styles to the undeformed lower grade Knob Hill rocks is still enigmatic and unexplained.

Attwood Formation

Rocks of the Attwood Formation are more restricted in the Greenwood area than the Knob Hill Complex, the main outcrop areas being around the northern slopes of Mount Attwood, the slopes of Rusty Mountain and Mount McLaren, and in the extreme southwestern corner of the map

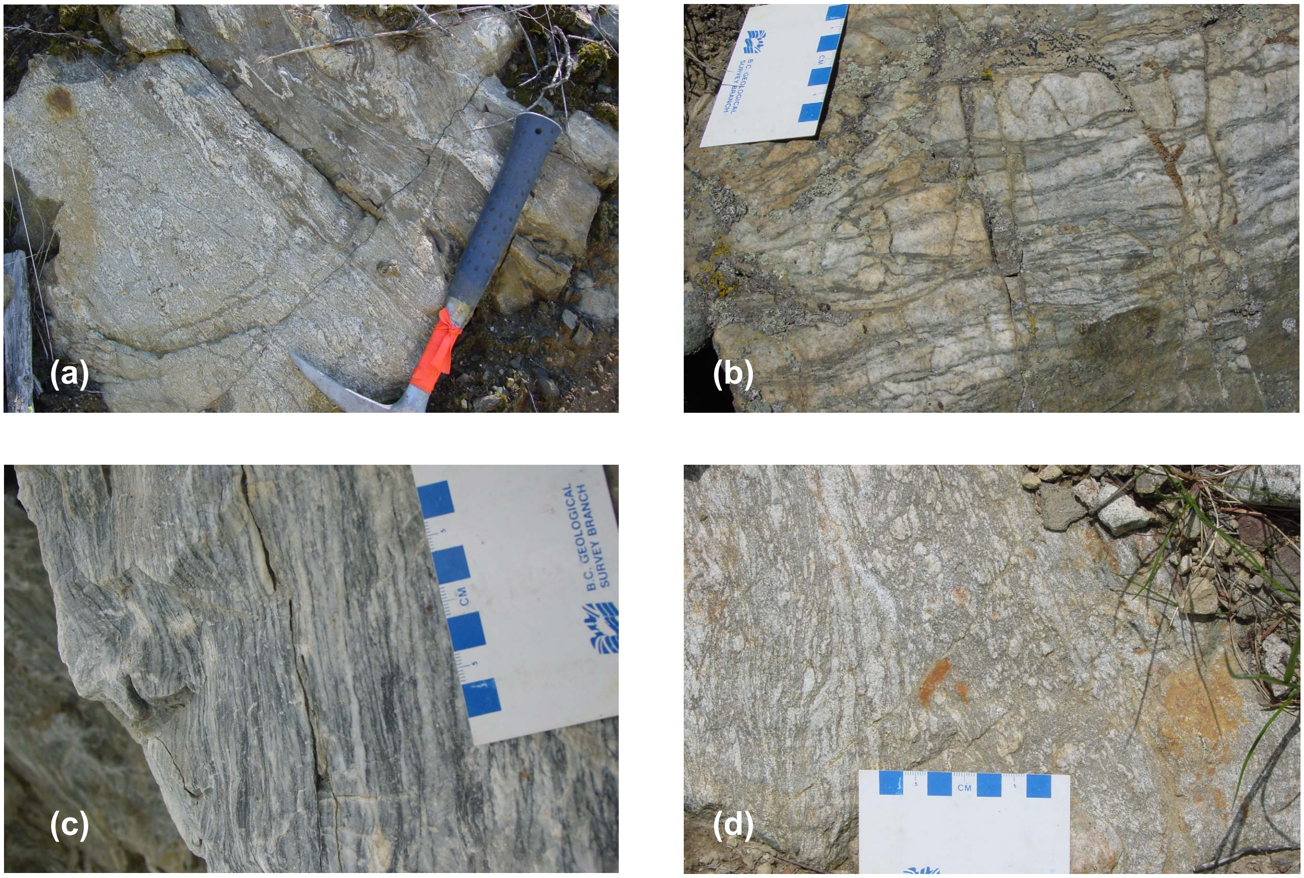

Figure 5. Rocks of the metamorphic unit of the Knob Hill Complex: a) biotite-quartz-feldspar gneiss, Windfall Creek (05NMA20-02; UTM Zone 11, 5430392N, 372191E, NAD83); b) metaquartzite (metachert?), Highway 3, Eholt Creek valley (05NMA26-12; UTM Zone 11, 5443713N, 383281E, NAD83); c) foliated marble, Highway 3, Boundary Falls (05NMA05-01; UTM Zone 11, 5435265N, 376209E, NAD83); d) quartz-biotite gneiss, Mount Roderick Dhu (05NMA09-22; UTM Zone 11, 5450126N, 382554E, NAD83).

sheet. The term Attwood 'Series' was introduced by Daly (1912) and refined by Little (1983) to Attwood Formation. Although the status of the Attwood was raised to the group level by Church (1986) and Fyles (1990), Little's definition is preferred here.

The Attwood Formation comprises an argillite-siltstone member, a limestone member and possible minor volcanic rocks. In all outcrop areas, the rocks are folded and the internal stratigraphy of the formation is unknown. Stratigraphic thickness is also unknown, though Little (1983) estimated it to be at least 400 m, with apparent thickness greater than 1200 m.

Fossil collections from the Attwood Formation limestone have yielded macrofossils and conodonts of Carboniferous to Permian age (Little, 1983; Church, 1986; Templeman-Kluit, 1989a). A Mississippian age is suggested for conodonts from a limestone along the Haulage Road (Orchard, 1997). No stratigraphic contact is found with the Knob Hill Complex and it is unclear what their original spatial or temporal relationships were. Monger *et al.* (1991) placed the Attwood, along with the Knob Hill, in the Okanagan subterrane of Quesnellia. However, Nelson *et al.* (1995) suggested that the clastic rocks of the Attwood show a greater affinity to the arc-derived clastic sedimentary rocks of the Harper Ranch subterrane.

ARGILLITE-SILTSTONE

The argillite-siltstone unit consists of fine-grained clastic sedimentary rocks, mostly black to grey argillite, lighter grey siltstone, dark grey to black chert and cherty argillite, and grey phyllite and slate. Laminations, thin bedding and graded beds are well developed in places, but may be obscured by slaty cleavage and fractures (Fig. 6). Minor sandstone, chert conglomerate and grey limestone also occur as interbeds.

Fine-grained dark grey siltstone or quartz wacke, with minor pebble conglomerate, crop out around Mount McLaren. This unit was assumed to be Jurassic by Little (1983), but included in the Attwood Formation by Church (1986) and Fyles (1990). Similar argillite, in a similar structural position in the footwall of the No 7 fault, is found around the Morning Star deposit in Washington, where they are correlated with the Lower Jurassic Archibald Formation of the Rossland Group (Caron, pers. comm., 2005).

LIMESTONE

Limestone is white to grey, fine to coarse-grained, variably recrystallized to saccharoidal marble. The limestone is generally massive, but may show faint streaking or laminations. Thin, pale green to white chert beds and black argillite occur as intercalations. Little (1983, page 8) also recorded the presence of chert granule limestone. Fossiliferous beds, occurring at various localities, have

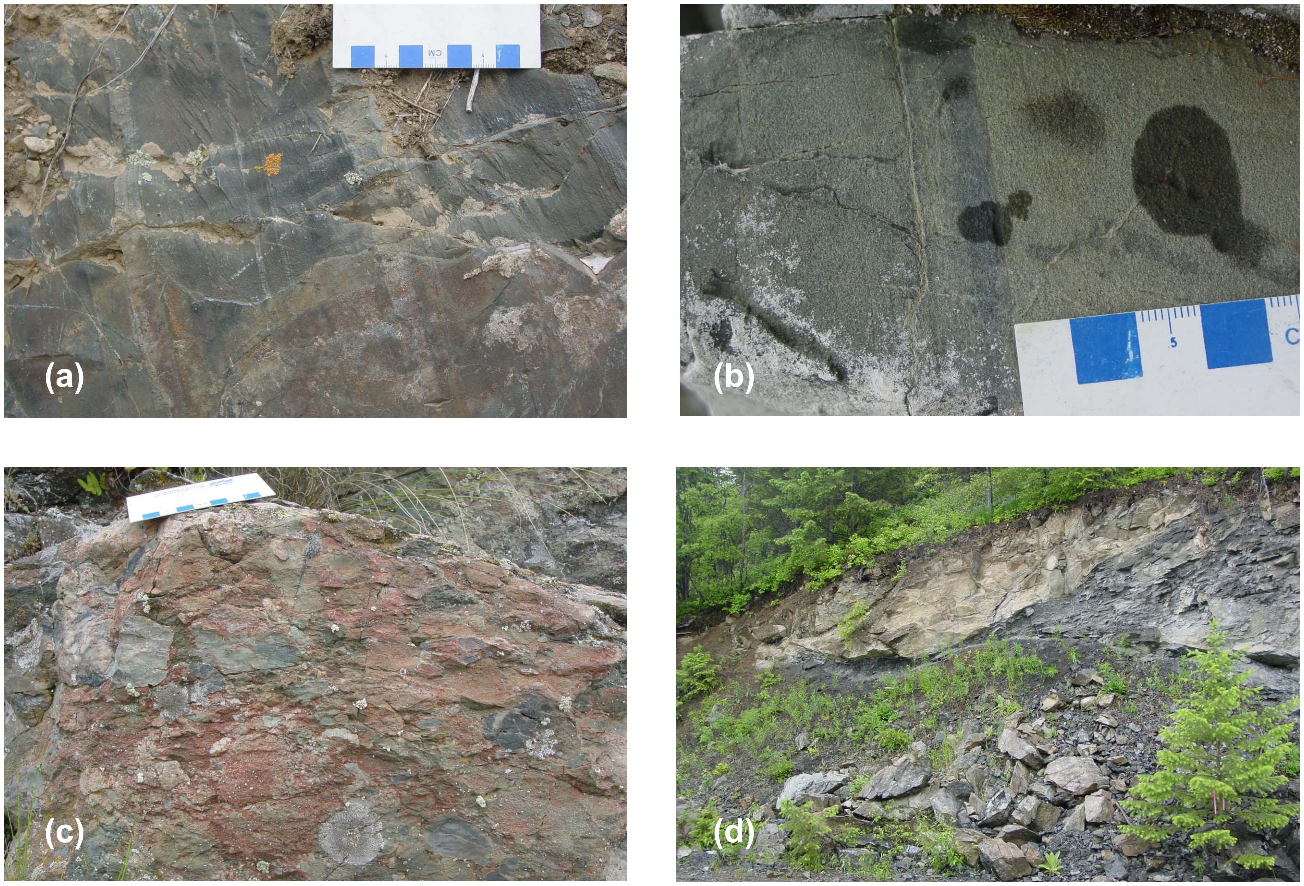

Figure 6. Attwood Formation rock types: a) slaty argillite-siltstone interbeds, Skomac mine (05NMA18-14; UTM Zone 11, 5435668N, 375126E, NAD83); b) graded sandstone-siltstone beds, Myers Creek area (05NMA 24-11; UTM Zone 11, 5430982N, 354727E, NAD83); c) limestone bed above argillite, Haulage Road (05NMA 03-10; UTM Zone 11, 5434200N, 384961E, NAD83); d) chert breccia, Skomac mine (05NMA 18-10; UTM Zone 11, 5435660N, 375038E, NAD83).

yielded corals, brachiopods, bryozoans and crinoids (Little, 1983).

VOLCANIC UNITS

A large proportion of the greenstone and metavolcanic rocks in the Greenwood area were assigned by Church (1986) to the Attwood Group [*sic*], though he later reassigned some to the Knob Hill (Dostal *et al.*, 2001). Fyles (1990), however, recognized some of the remaining 'Attwood' metavolcanic rocks as actually belonging to the Triassic Brooklyn Formation, and included the rest of the basalt in the Knob Hill, following the earlier suggestion of Little (1983).

However, a sliver of volcanic rocks, apparently in the immediate footwall of the Lind Creek fault (see Fig. 7 for location of faults), may be in the Attwood Formation (Fyles, 1990). Outcrops in this unit along the Haulage Road are fine-grained, massive aphanitic greenstone essentially indistinguishable from the Knob Hill greenstone. Contacts with limestone and argillite to the south were not found, and the status of this greenstone is presently unclear. Petrochemistry may help reveal whether or not it is akin to the Knob Hill greenstone.

Orange to buff-coloured muscovite schist and buff silty tuff are interbedded with grey argillite and cherty siltstone within the Attwood Formation in the Myers Creek area, in the southwest corner of the map sheet. These are believed to be felsic tuff horizons, although similar rocks are not seen elsewhere in the map area.

STRUCTURAL RELATIONSHIP OF PALEOZOIC UNITS

The Paleozoic rocks of the Greenwood area are preserved in a series of five northward-dipping thrust sheets (Fig. 7). Many of the bounding thrusts are marked by serpentinite layers or pods. Tertiary extensional faulting has disrupted and modified the thrust sheets and makes correlation uncertain between the western and eastern halves of the Greenwood map sheet. Detailed descriptions of the thrust sheets have been provided by Fyles (1990) and only a brief summary is given here. The sheets are informally numbered from south to north, structurally from bottom to top.

In the eastern part of the map area, sheet 1 straddles the Canada – United States border, being bounded to the north by the No 7 fault and to the south by the White Mountain fault (Stoffel *et al.*, 1991). It comprises probable Attwood Formation sedimentary rocks overlain by Triassic Brooklyn Formation volcanic rocks. In the west, a similar sheet of Attwood Formation rocks, bounded to the north by the Myers Creek fault, is here correlated with thrust sheet 1.

Sheet 2 is bounded by the No 7 fault as footwall and the North Mount Wright fault as hangingwall. Several other

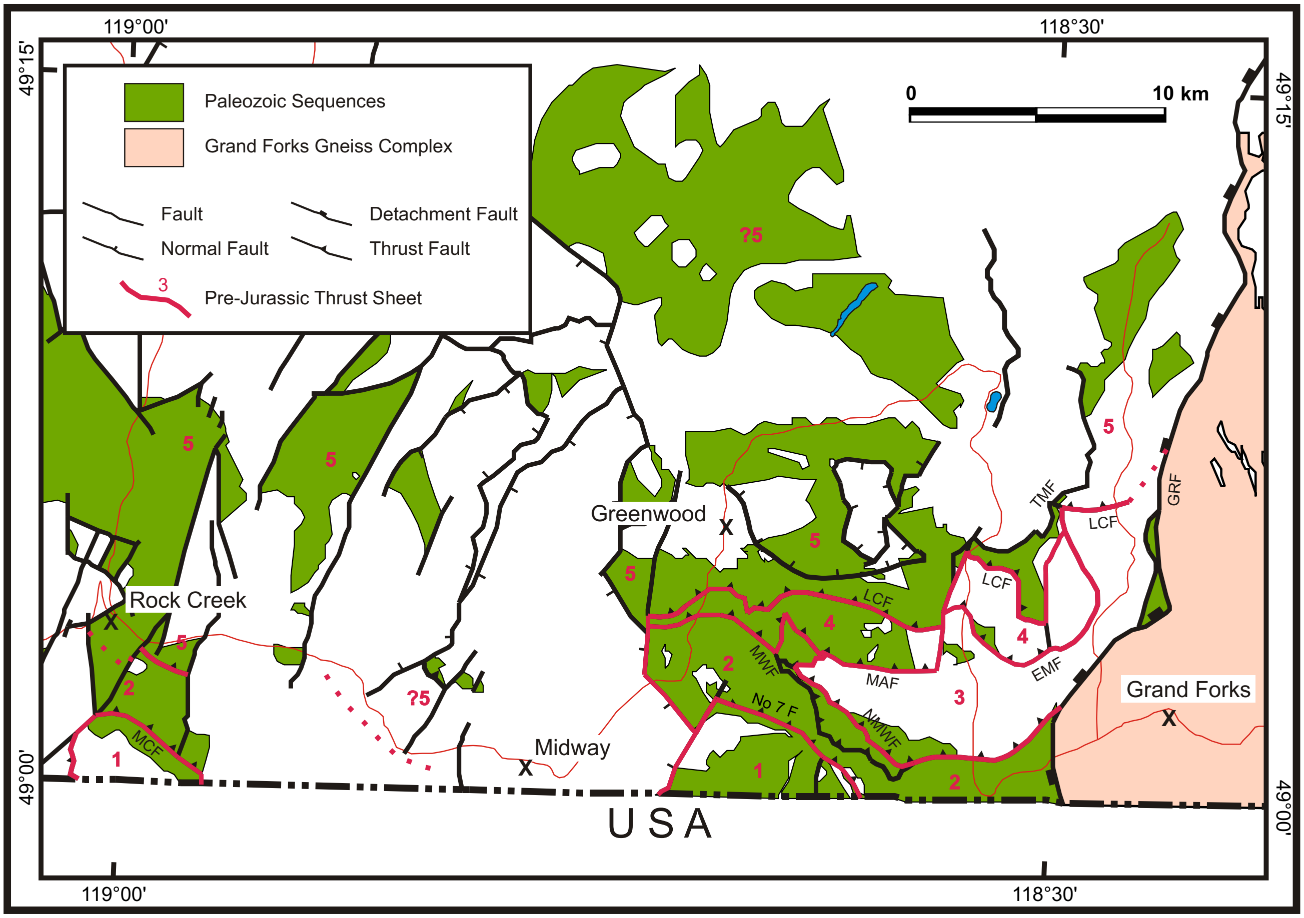

Figure 7. Main structural elements of the Greenwood area, outlining the five major thrust sheets (numbered 1–5) that contain the Paleozoic sequences (modified from Fyles, 1990). Abbreviations: GRF, Granby River fault; LCF, Lind Creek fault; MAF, Mount Attwood fault; MCF, Myers Creek fault; MWF, Mount Wright fault; NMWF, North Mount Wright fault; No 7 F, No 7 fault; TMF, Thimble Mountain fault.

mapped thrusts also occur internal to this sheet. The sheet comprises Knob Hill Complex metamorphic rocks with minor Brooklyn Formation. The Knob Hill Complex metamorphic rocks south of Rock Creek, and above the Myers Creek fault, are here correlated with sheet 2. The hangingwall thrust is not exposed but is postulated based on the contrast in metamorphism and deformation with the gabbro, greenstone and chert to the north of Rock Creek.

Sheets 3 and 4 only occur east of Greenwood. Sheet 3 comprises mostly Brooklyn Formation strata unconformable on Attwood Formation, bounded by the North Mount Wright and Mount Attwood faults. Sheet 4 similarly consists of Attwood and Brooklyn Formations, but is broken into several fragments by northerly trending Tertiary faults. The footwall thrust is the Mount Wright fault in the west and the Mount Attwood and Eagle Mountain faults to the east. The Lind Creek fault is the hangingwall thrust.

Sheet 5 contains the bulk of the Knob Hill Complex rocks in the map area, with unconformably overlying Brooklyn Formation. Knob Hill Complex outcrops north of the Kettle River in the western half of the map are part of this thrust sheet, although separated from the eastern area by Tertiary faults. The inlier of dominantly Brooklyn Formation rocks north of West Midway is also tentatively included in sheet 5, though it may belong to sheet 1.

Chert-argillite unit outcrops along the northern side of Highway 3 in the Eholt Creek valley are much higher in metamorphic grade and more deformed than Knob Hill units to the south on Montezuma Ridge, and are comparable to the rocks of the metamorphic unit. Such a sharp contrast of metamorphic grade may suggest a major structure along the Eholt Creek valley, perhaps another thrust. However, the Knob Hill units southeast of Jewel Lake are lower grade and appear to show a more gradual transition northward into the higher grade metamorphic rocks of Mount Roderick Dhu and Windfall Creek. Without more convincing evidence, all these units are considered to probably be part of thrust sheet 5.

The age of the thrust structures is still uncertain. Clasts of nearly all Paleozoic rock types, including serpentinite, are found in the Ladinian Brooklyn Formation conglomerate, indicating uplift and juxtaposition of the Paleozoic strata by the Middle Triassic. However, the involvement of Brooklyn Formation strata in the thrust sheets shows that the main thrusting event occurred, or continued, into post-Ladinian time. Diorite and granodiorite stocks of the Nelson suite intrude the thrust sheets, providing a minimum age for thrusting of 164–169 Ma (Lambert, 1989).

Church (1992) reported a discordant U-Pb zircon age of 199.4 ±1.4 Ma from the Lexington porphyry. This is possibly intrusive into the No 7 fault (see below), suggesting that thrusting took place prior to Jurassic time. The Chesaw fault in Washington is interpreted to be the continuation of the Myers Creek fault (Cheney *et al.*, 1994). It is apparently cut by the Loomis pluton, which has yielded a discordant K-Ar hornblende age of 194 ±6 Ma (Rinehart and Fox, 1972; Stoffel, 1990). However, the Chesaw fault also cuts the Ellemehan Formation, which has been correlated with the Sinemurian to Pliensbachian Elise Formation of British Columbia (Read and Okulitch, 1977; Stoffel *et al.*, 1991), though lacking paleontological support.

LEXINGTON PORPHYRY REVISITED

The Lexington mining camp comprises up to eleven Cu-Au porphyry deposits in British Columbia and Washington, hosted by the Lexington porphyry within the No 7 fault zone. Mineralization stretches in a linear belt from the No 7 mine in the northwest to the Lone Star mine, in Washington, in the southeast. Exploration and development in this camp started in 1890 and continues to this day. Important reviews of mineralization and historical development were provided by Church (1970, 1986) and Seraphim *et al.* (1995).

The No 7 fault is marked by a thick serpentinite sheet along its length from McCarren Creek to the United States border. Along Goosmus Creek, the serpentinite is apparently split in two by the intrusion of a quartz porphyry body known as the Lexington porphyry (Church, 1992). The quartz-feldspar porphyry body in the footwall of the No 7 fault near the confluence of McCarren and Gidon creeks has been correlated with the Lexington quartz porphyry. The quartz-feldspar porphyry is, however, marked by large pink K-feldspar phenocrysts that are apparently absent from the type Lexington porphyry, which raises doubts about their correlation. Uranium-lead zircon geochronometry and petrochemistry are being conducted to help resolve this issue.

Several authors have mapped areas of andesitic to dacitic volcaniclastic rocks around some of the mines in the Lexington camp (*e.g.*, Church 1986, Fig. 9) and equivalents in Washington (*e.g.*, Morning Star deposit; Caron, pers. comm., 2005). Dacitic volcaniclastic rocks that host mineralization are also reported by company geologists in drillcore from the area (Butler, 1997; Cowley, 2004). Seraphim *et al.* (1995), however, asserted that these units at Lexington are not original volcanic rocks but the result of cataclasis of the porphyry within the fault zone, although they do allow for “the presence of xenoliths and screens of old volcanic rocks in the intrusion.” Ongoing petrological and petrochemical studies are directed at this problem.

The recognition of these units as true volcanic rocks could have significant implications, not only for regional correlation and tectonic history but also for the possible potential for volcanogenic massive sulphide (VMS) deposits. Similar felsic volcaniclastic rocks are not found in the immediate map area and correlative equivalents are not easily recognized in the boundary region generally. Possible fine-grained buff tuff was found in the Attwood Formation in the Myers Creek area (see above), but no coarser lapilli tuff was found. If the volcaniclastic rocks are coeval with the 200 Ma Lexington porphyry, it may suggest that they are correlative with the Lower Jurassic Elise Formation of the Rossland Group. Church (1992) draws a comparison between the Lexington porphyry and felsic intrusions of similar age in the Nelson area (Dunne and Höy, 1992). Felsic volcanic rocks overlying the stratabound Lamefoot Cu-Au deposit have yielded an Ar/Ar plateau age of 195 Ma on sericite (Rasmussen, 2000) and have been correlated with the Elise Formation, as have felsic rocks at the Morning Star (Caron, pers. comm., 2005). However, in the Rossland area itself, the Elise Formation comprises mafic to andesitic volcanic rocks and lacks any significant felsic rocks (Höy and Andrew, 1989; Andrew *et al.*, 1990).

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