Redefining the Southern Nicola Group: Petrographic and Structural Characterization of the Eastgate-Whipsaw Metamorphic Belt, Southern British Columbia (NTS 092H/02E)

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KEYWORDS: Nicola Group, Eastgate-Whipsaw metamorphic belt, Manning Park, Princeton, Quesnel terrane

INTRODUCTION

The Late Triassic–Early Jurassic Nicola Group in south-central British Columbia and its northern continuation, the Takla Group, constitute the volcanic arc that defines the extent of the Quesnel terrane (Figure 1). It hosts economically significant alkalic porphyry copper-gold deposits, including those at Copper Mountain, Highland Valley, Mount Milligan and Mount Polley. Past geological mapping of the Nicola Group by Rice (1947), Preto (1972), Mortimer (1987) and Monger (1989) established its distribution and divided it into three differing belts. However, the southwesterly portion of the Nicola Group, south of the town of Princeton, on the eastern boundary of Manning Park, was not assigned to any of the three major belts, although Mortimer (1987) suggested it may be a part of the calcalkaline western belt.

Rocks adjacent to the Jurassic–Cretaceous Eagle Plutonic complex, along the margin of Manning Park, differ significantly from other nearby Nicola Group outcrops and have been assigned to the Eastgate–Whipsaw metamorphic belt by Massey et al. (2009a). Key differences between this area and the supposed affiliated Nicola Group include higher metamorphic grade in the metamorphic belt (upper greenschist to lower amphibolite facies, compared to lower greenschist in typical Nicola), stronger deformation, differing rock types and the presence of several volcanogenic massive sulphide (VMS) deposits not usually seen in Nicola rocks (e.g., the Red Star and S and M VMS properties). There is a notable resemblance in lithology, metamorphism and setting with the Permo–Triassic Sitlika–Kutcho Formation, a known VMS-hosting unit (e.g., Kutcho Creek), emplaced along the margins of the Quesnel and Cache Creek terranes; the Sitlika has been shown to extend south as far as Ashcroft (NTS 092I), only 150 km northwest (along strike) of this 'suspect' metamorphic belt. This ongoing MSc project is focused on a detailed geological analysis of the poorly documented metamorphic belt; this paper is reporting preliminary observations on the petrography of the metamorphic rocks and overall structure of the belt.

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RECENT WORK

Mapping in 2008 focused on determining the boundaries and constraining the rock types between definite Nicola Group exposures, units of the metamorphic belt and the Eocene Princeton Group. The metamorphic belt has been divided into three general units (Massey et al., 2009a): the eastern amphibolite belt, the central quartzite belt and the western metavolcanic-metasedimentary belt (Figure 2). The metamorphic belt's bounding contacts and the contacts between the three compositional belts all strike in a northerly direction. A dominant foliation, also northerly trending and parallel to the contacts, has been noted across the belt striking, on average, towards 165° and dipping increasingly steeply towards its western edge. Although few contacts are exposed, a definite fault contact, named the Similkameen Falls fault, was mapped between augite-phyric, mildly to undeformed Nicola Group volcanic rocks and the eastern edge of the metamorphic belt, making a lithofacies gradation somewhat less likely, as previously believed (Rice, 1947; Preto, 1972; Monger, 1989). Mapping in 2009 helped to further constrain the limits of the belt, which abruptly pinches out to the north where it is intruded by muscovite granite of the Eagle Plutonic complex (Massey and Oliver, 2010).

PETROGRAPHY

Select samples from the 2008 field season were used to study the petrography of the mapped units (Figure 2). The petrographic descriptions presented here (listed in Table 1) are discussed in order starting from westerly samples and moving to the east. The samples studied are categorized according to the three generalized units within the Eastgate–Whipsaw metamorphic belts: the amphibolite belt, the quartzite belt and the metavolcanic-metasedimentary belt (Massey et al., 2009a). These sample groupings may be subject to reinterpretation based on subsequent mapping and ongoing petrographic and petrochemical studies.

The intense metamorphism and deformation experienced by this belt have overprinted any primary textures that once existed in the rocks. The only possible relict texture noted in the field is the bedding boundaries between differing compositional layers, which often strike subparallel to the dominant 165° foliation in the metamorphic belt. However, this bedding may not reflect the original orientation, depending on the extent to which the metamorphic and deformation events have mobilized and transposed these relations. This has yet to be determined.

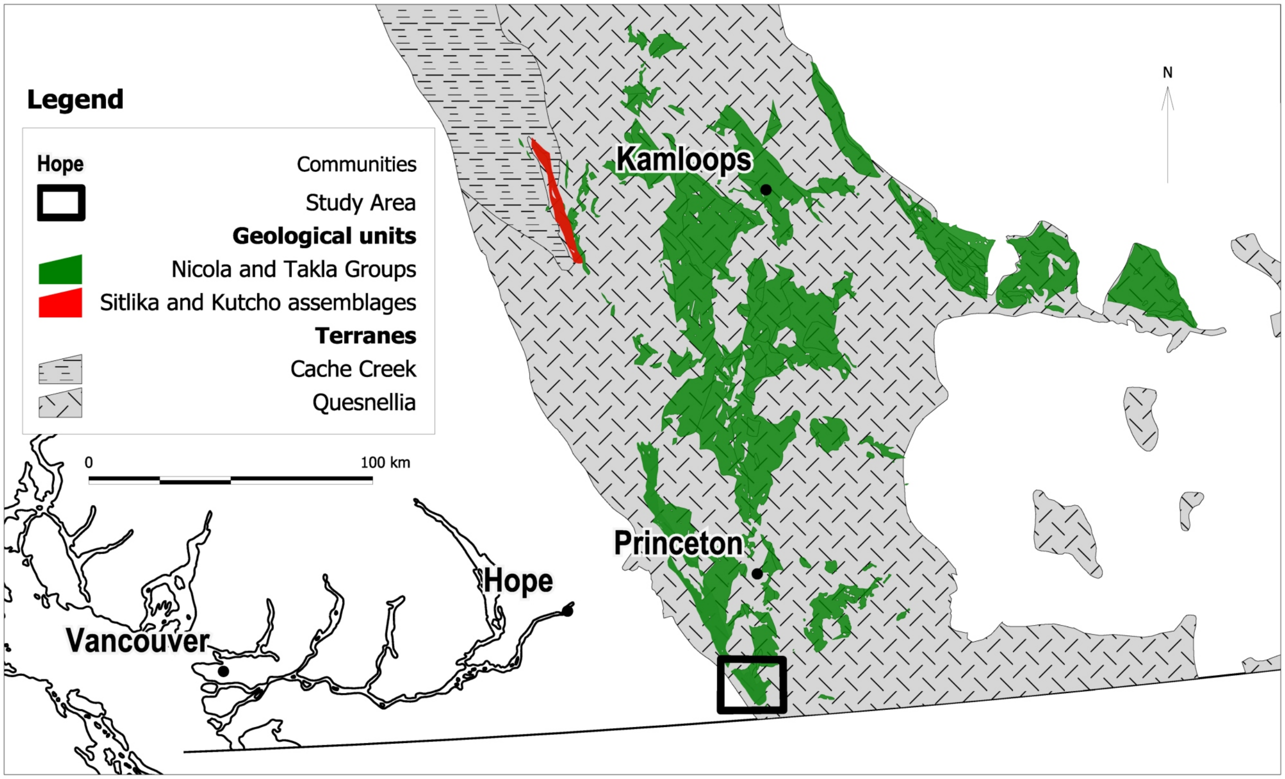


Figure 1. Location of study area, southwestern margin of Quesnellia, southern British Columbia.

Amphibolite Belt

There are several examples of amphibole-rich rock types within the Eastgate–Whipsaw metamorphic belt. The most consistent is a belt of northwest-trending rocks, tens of metres wide, on the westernmost edge of the metamorphic belt (Figure 2), in contact with the Eagle Plutonic complex. In outcrop, the belt is composed of black, actinolite+epidote-rich schistose rocks, which occur across the entire western unit. Between the 1–3 cm thick, dark layers are thin bands (only a few millimetres thick) of white quartzofeldspathic material. These two compositionally variable layers have distinct, although gradational, boundaries (Figure 3).

The felsic layers are composed of plagioclase, some quartz, interstitial calcite and minor actinolite and epidote. The fine grain size precludes the determination of relative proportions of plagioclase to quartz. The dark layers consist predominantly of poikiloblastic euhedral actinolite, epidote granules, anhedral oxides, magnetite, minor secondary biotite associated with the amphibole and small amounts of fine-grained, interstitial feldspathic material. Although the gradual grading in composition between the layers may be indicative of a primary lithological control, a clear protolith cannot be determined since both para- and ortho-amphibolites commonly display this banded feature (Evans and Leake, 1960). Further study into the variation of chemical trends (Leake, 1964) and the distributions, and contents, of major and trace elements (Shaw and Kudo, 1965) of the amphibolite will be undertaken to aid in determining the nature of the protolith.

AMPHIBOLITE INTERBEDS IN QUARTZITE UNITS–QUARTZITE BELT CONTACT

Amphibole-rich interbeds in quartzite were mapped at the boundary between the amphibolite belt and the quartzite belt (Figure 4). It has been noted in the literature that thin bands of amphibole-rich layers are commonly found in metamorphosed sedimentary rocks and are thought to be associated with chemical reactions rather than simple depositional features (Preto, 1970). It is likely that observations on closed-system metasomatic influences made by Orville (1969) on similar interbeds do not apply here since no significant calcareous sedimentary units were observed in the area. Further investigation using chemical analysis will help to better understand their formation.

Quartzite Belt

East of the amphibolite belt is a thick package of siliceous metamorphic rocks. The common, monomineralic samples are categorized as biotite quartzite (Figure 5) and occur in the southwestern section of the quartzite belt. The orange-white samples in this area all have a fine-grained, sugary texture with the minor platy biotite aligned parallel to the regional foliation. Moving away from the southwestern corner of the quartzite belt, either in an easterly or northerly direction, the composition in the quartzite belt units begins to vary. The mineralogy of the rock units to the north and east is changed by the appearance of actinolite, some garnet, oxides and, on the far-eastern side of the quartzite belt, chlorite. The ratio of siliceous material to the other mineral components decreases to such a degree that, on the eastern edge of the quartzite belt, the rock units are

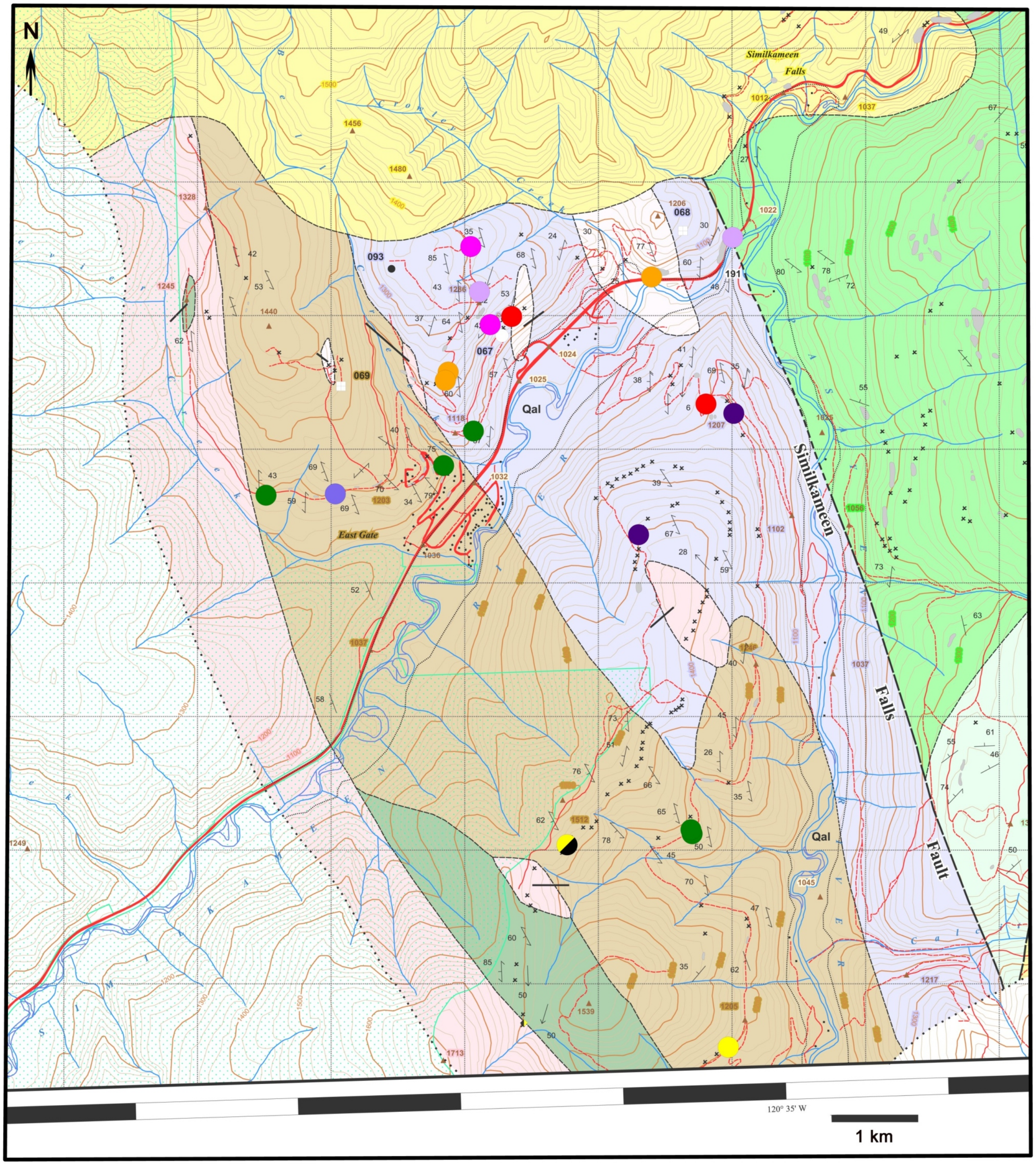


Figure 2. Distribution of reviewed mineral assemblages from study area in the Eastgate–Whipshaw metamorphic belt, southern British Columbia. Dot colours: dark purple, actinolite+biotite+epidote+chlorite schist with magnetite porphyroblasts; medium purple, chlorite+ilmenite+magnetite+apatite+clinozoisite quartz-schist with feldspar phenocrysts; light purple, chlorite+calcite+clinozoisite quartz-schist with minor biotite or muscovite and quartz+feldspar phenocrysts; pink, muscovite+chlorite quartz-schist with quartz phenocrysts; orange, feldspar porphyry with minor amounts of micaceous phases; red, foliated feldspar/quartz+chlorite+epidote+actinolite+biotite schist with feldspar phenocrysts; yellow, biotite quartzite; banded yellow, quartzite with amphibolite interbeds; green, amphibolite. Metamorphic belt geology derived from Massey et al. (2009b): light green, amphibolite belt; light brown, quartzite belt; light blue, metavolcanic-metasedimentary belt. Other units: pink, Eagle Plutonic complex; light lime green, Nicola Group; yellow, Princeton Group.

Table 1. Common rock types in the Eastgate–Whipsaw metamorphic belt, southern British Columbia.

Belt unit	Description
Amphibolite belt	act+ep+pl+bio+qz+cal schist
Quartzite belt	
major units	bt qte
	bt+mag qte
	bt qtz-schist
	bt+act qtz-schist
	qtz+act+bt schist
minor units	chl+ilm+czo+ap qtz-schist with relic qtz clasts
	act+ep+pl+bt+qtz+cal schist
	act+pl/qtz+ep+chl+bt+ilm schist
Metavolcanic-metasedimentary belt	
mafic units	act+ep+cal+pl/qtz+ilm+bt schist (metabasite)
low mica units	bt+oxide+ep+ms qtz/fel-schist with pl porphyroclasts and qtz relics (metarhyolite)
	chl+bt qtz/pl-schist with sericitized pl porphyroclasts and qtz relics
	qtz/fel-schist with minor bt+chl, pl porphyroclasts and cumulophyric clusters of pl+bt+chl+oxide
low to no potassium units	qtz+chl+ilm schist with relic qtz clasts and ap porphyroblasts
micaceous units	qtz+ms+chl+ilm+ap schist with relic qtz clasts
	qtz/fel=chl+ep+act+bt schist with pl porphyroclasts and minor relic qtz clasts
	qtz/fel+act+chl±bt+ms+ilm schist with pl porphyroclasts and minor relic qtz clasts
	act+qtz/fel+chl+mag+bt schist

Abbreviations: act, actinolite; ap, apatite; bt, biotite; cal, calcite; chl, chlorite; czo, clinozoisite; ep, epidote; fel, feldspar; ilm, ilmenite; mag, magnetite; ms, muscovite; pl, plagioclase; qtz, quartz; qte, quartzite

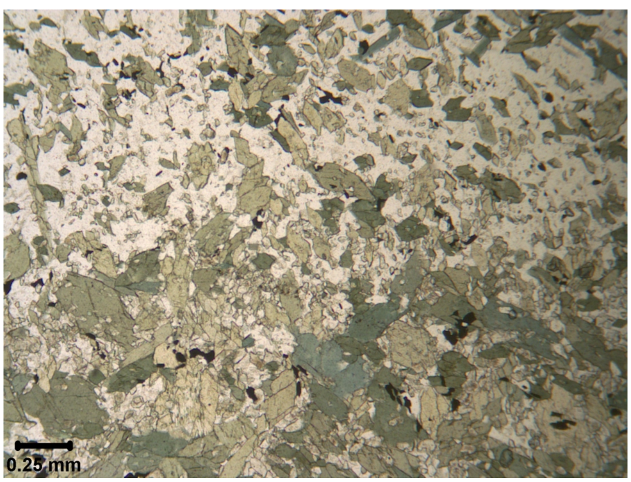


Figure 3. Thin-section photomicrograph of a mafic layer in amphibolite grading into a more felsic layer, Eastgate–Whipsaw metamorphic belt, southern British Columbia (field station 08SOL24-01, UTM Zone 10, 5445656N, 672513E, NAD 83).

Figure 4. Outcrop photo of an amphibolite interbed in a quartzite unit, Eastgate–Whipsaw metamorphic belt, southern British Columbia (field station 08NMA17-06, UTM Zone 10, 5442201N, 675785E, NAD 83).

no longer proper quartzite but quartz-schist. The strike of the schistosity also varies slightly in the southeastern corner of this belt by veering away from 165 and striking closer to 190 , this change has been interpreted as indicating the presence of a possible fold (Massey et al., 2009a).

More typically in outcrop, the composition of the unit will be consistent, changing gradually over tens of metres, although there are some examples of layered outcrops where the units will vary slightly in composition over thicknesses of 0.5–1 m. However, the typical trend in bulk compositional change is occurring gradually over the distance of the quartzite belt.

CHLORITE QUARTZ-SCHIST INTERBED

In the north-central section of the quartzite belt (Figure 2), the units are still quartz rich and predominantly actinolite+biotite+magnetite bearing, but also contain significant aluminum-, potassium-, calcium- and iron-bearing

Figure 5. Outcrop photo of a biotite-quartzite, Eastgate–Whipsaw metamorphic belt, southern British Columbia (field station 09THS02-02, UTM Zone 10, 5441526N, 675973E, NAD 83).

phases. Moving towards the east in the northern section of the map area, interbedded units lacking any potassium-bearing phases become increasingly abundant. These thin (10–20 cm thick) interbeds are equigranular, fine-grained chlorite+ilmenite quartz-schist with minor apatite+ clinozoisite. They are interlayered between actinolite+ biotite+chlorite quartz-schist (Figure 6) and seem to have sharp contacts between the differing compositions still containing potassium-bearing mineral phases.

The lack of potassium possibly reflects a change to a more volcanic source or, at least, to a reduced sedimentary input. Further to the east, chlorite continues to be a significant mineral phase in the schist layers, along with variable amounts of actinolite and biotite.

MAFIC SCHIST

Also along the boundary between the quartzite belt and the metavolcanic-metasedimentary belt (Figure 2), there is a cropping-out of a few thick beds of massive amphibole-rich rocks, often 5–10 m thick. Their mineralogy includes actinolite, epidote, ilmenite, plagioclase, calcite and quartz, with lineations defined by the more elongate minerals. In thin section, some of the samples are texturally and compositionally similar to the western margin amphibolite, as they have layers of differing composition and a significant quartzofeldspathic component (see Figure 3). They are also heterogeneous and contain thin plagioclase-, quartz- and calcite-rich layers within more mafic bands rich in actinolite and epidote. However, this mafic schist in hand sample does not appear black and schistose like the amphibolite to the west, but rather much more grey-green, hard and massive.

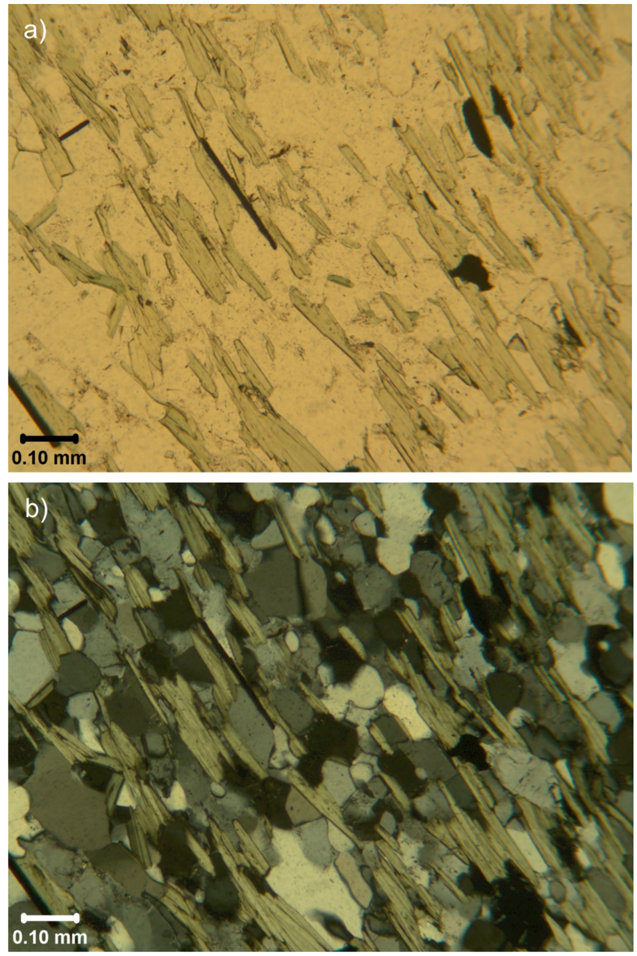


Figure 6. Thin-section photomicrographs of a chlorite+ilmenite quartz-schist unit found between units of actinolite+biotite+chlorite quartz-schist, Eastgate–Whipsaw metamorphic belt, southern British Columbia: **a)** plain-polarized light thin section; **b)** cross-polarized light thin section (field station 08SOL24-02, UTM Zone 10, 5445666N, 673032E, NAD 83).

Two other outcrops of mafic schist along this central boundary are more mafic in composition, being fine-grained, massive and mostly homogeneous. In order of abundance, it is composed of actinolite, epidote plagioclase, calcite and quartz. Small, flat planes of chlorite+biotite clusters approximately a few millimetres thick and 10–15 cm wide are found sporadically in outcrop. In both outcrop and thin section, these units look like typical greenstones.

Metavolcanic-Metasedimentary Belt

The eastern side of the metamorphic belt is made up of a variety of schists of differing compositions (Figure 2). Unlike the quartzite belt, the metavolcanic-metasedimentary belt does not appear to have any obvious compositional trend. The Red Star VMS deposit (067 on Figure 2) occurs in the north-central area of the belt, where units proximal to the deposit have a felsic composition. As the outcrops become more distant from the deposit, in either a southwesterly or southeasterly direction, their compositions often become increasingly mafic. The variation in composition seems to occur in clusters of more felsic schist surrounded by more common intermediate to mafic schist. A full description of each common rock type found in this belt is given below.

QUARTZ-CHLORITE SCHIST

Similarly to the interlayers found in the quartzite belt, a few outcrops found in this belt also lack potassium, forming quartz+chlorite schist with quartz and plagioclase porphyroclasts. Some units have no biotite or muscovite at all, while others have only small amounts (1% or less). The typical mineral assemblage for this unit is a chlorite quartz-schist with minor apatite, ilmenite and clinozoisite. In outcrop, this unit is a green schist with visible porphyroclasts. The fine-grained schist matrix is typically equal parts chlorite to quartzofeldspathic material. Two units of this composition were mapped, one of them in the very northeastern edge of the belt, while the second originated directly in the Red Star showing itself (067 on Figure 2).

In the sample from the Red Star showing, the porphyroclasts of quartz are recrystallized and the relict shapes often appear quite round. However, the plagioclase porphyroclasts are fresh-looking, euhedral laths with sharp edges. The well-defined foliation, expressed particularly by chlorite in this unit, wraps around the quartz and plagioclase porphyroclasts. Their appearance suggests that the quartz-eyes and plagioclase laths were present before the development of that particular foliation. Whether the plagioclase crystals are definitely porphyroclasts or porphyroblasts will require a detailed study into the specific chemistry of the feldspars.

FELDSPATHIC UNITS

Feldspathic units are found as thick packages proximal to the Red Star showing (067 on Figure 2) on the northeastern side of the study area (red and pink dots on Figure 2). In outcrop, the units are light in colour, often white or a light pink with minor green siliceous bands. They either have very thin planes (less than 0.5 mm thick) of biotite, muscovite and chlorite defining the foliation or lack micaceous layers and a penetrative foliation, only showing alignment in minor amounts of platy minerals. The matrix is fine grained to very fine grained and even though dynamic recrystallization has affected the texture, the differing grain sizes is likely due to a primary grain-size influence. The finer grained units have undergone more alteration, since the plagioclase porphyroclasts and the matrix are more sericitized. Grain boundary migration can often be noted in the matrix, while some are so fine grained that they become mylonitic. All of the units have relatively large (3–4 mm) porphyroclasts of plagioclase (3–5% of rock) that are rounded and mantled by biotite, chlorite and recrystallized quartzofeldspathic material (Figure 7). The plagioclase porphyroclasts have undergone some form of deformation since they have developed subgrain boundaries. There are also occasional relict quartz porphyroclasts (1% of rock) that are now coarsely recrystallized. Cumulophyric clusters of feldspar, anhedral oxides, calcite and biotite, on the order of 3–4 mm in width, are also commonly found (Figure 7).

QUARTZ+FELDSPAR+CHLORITE+EPIDOTE SCHIST

This unit is a more mafic version of the feldspathic units described above. Dynamically recrystallized, blue quartz porphyroclasts and brittlely deformed, plagioclase porphyroclasts, with red oxide in cracks, are found in a matrix of fine-grained recrystallized plagioclase, quartz, chlorite, epidote and some biotite (Figure 8). Biotite is usually located on the outer edge of the plagioclase porphyroclasts and is often being replaced by chlorite. The feldspars have developed microfaults, and actually have sections broken off and pulled apart; the subsequent cracks are filled with oxides and give the plagioclase crystals an orange-pink appearance. A fabric is apparent in this rock due to mineral alignment, but this unit does not tend to break on even planes.

MUSCOVITE+CHLORITE QUARTZ-SCHIST

Some schist in the volcanic package has a more felsic composition and forms muscovite+chlorite quartz-schist with notable blue-hued quartz-eye porphyroclasts.

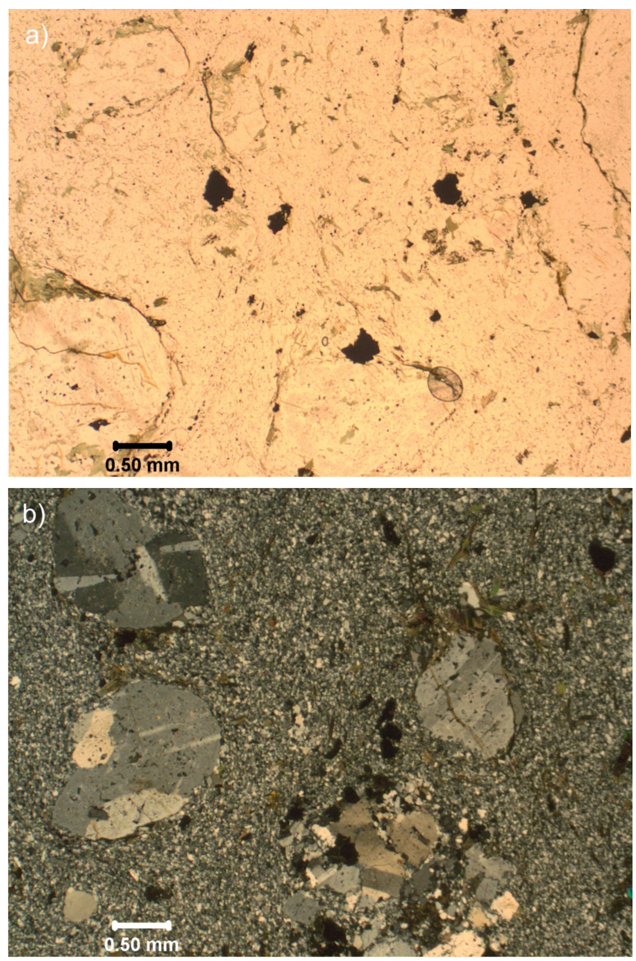


Figure 7. Thin-section photomicrographs of a feldspathic unit in the metavolcanic-metasedimentary belt of the Eastlake–Whipsaw metamorphic belt, southern British Columbia: **a)** plain-polarized light thin section showing porphyroclasts and cumulophyric clusters; **b)** cross-polarized light thin section (field station 08NMA21-01, UTM Zone 10, 5447289N, 675398E, NAD 83).

Using the mineralogy and presence of feldspar porphyroclasts as evidence, the eastern side of the metamorphic belt appears to be composed of volcanic or volcaniclastic rocks with varying amounts of clastic input. The majority of the schist contains a significant amount of feldspathic material (55–70% in the matrix). The unit's matrix has undergone significant dynamic recrystallization, judging by the grain sizes and textures on the grain boundaries. Finer grain sizes, combined with the grain boundary recrystallization textures, suggest that some samples are perhaps mylonitic. It is difficult to tell based solely on this grain size as it may be reflecting the primary grain size of the protolith rather than just how extensive recrystallization may have been.

ALTERATION

There has also been irregular alteration occurring in certain areas of the belt, as shown by sericitized feldspar porphyroclasts 7 m away from a similar outcrop with relatively fresh feldspar. Extensive veining does occur in clusters proximal to known showings, for example Red Star and Knobb Hill (067 and 069 respectively on Figure 2), with associated oxidization. Alteration is also noted near the fault in the form of sericitization and secondary calcite associated with calcite veining, and near the Red Star showing in the form of sericitization and oxidization.

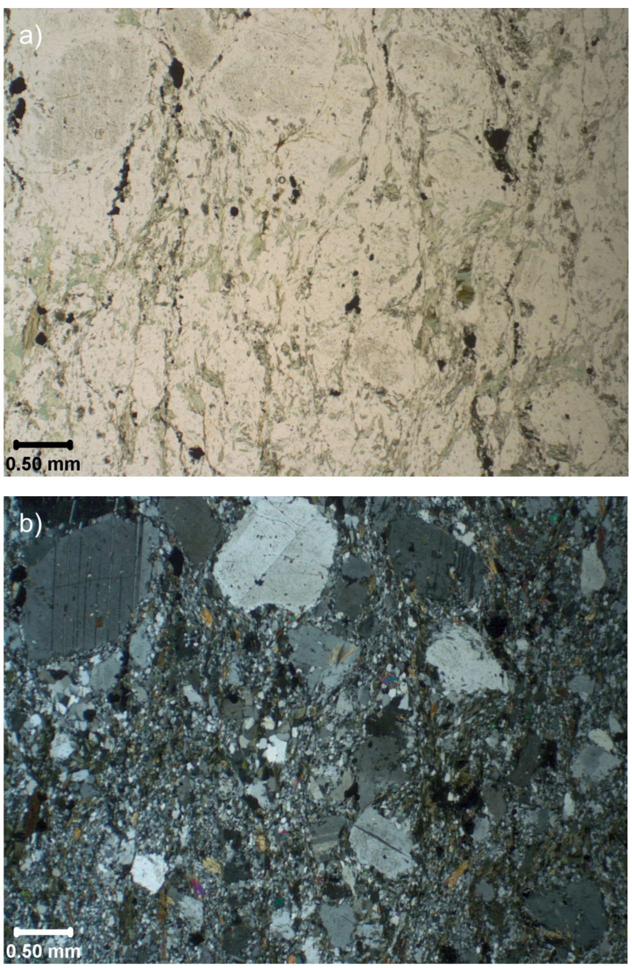


Figure 8. Thin-section photomicrographs of a quartz+ feldspar+chlorite+epidote schist with sericitized plagioclase porphyroclasts from the Eastlake–Whipsaw metamorphic belt, southern British Columbia: **a)** plain-polarized light thin section; **b)** cross-polarized light thin section (field station 08SOL23-04, UTM Zone 10, 5446993N, 674351E, NAD 83).

STRUCTURE

As well as the dominant northwest-trending foliation noted throughout the belt, a secondary schistosity was observed in some outcrops (Figure 9a). The strikes appear to be similar in the field, with the weaker foliation having a slightly steeper dip. Moving east to west across the metamorphic belt, the dip of the primary foliation tends to steepen. Observation of thin sections consistently reveals both foliations in samples. Crenulation cleavage is present in many schists with adequate mica and/or chlorite (Figure 9b). In the more felsic micaceous schist, the dominant schistosity consists mostly of muscovite while the weaker, older schistosity is associated with chlorite and muscovite. The more mafic schist commonly displays two lineations through two orientations of actinolite needles, one overprinting the other. Another phase of actinolite also occurs which cuts across the foliations. These actinolite needles have grown at a later stage and have not been affected by any deformation likely to have caused them to align.

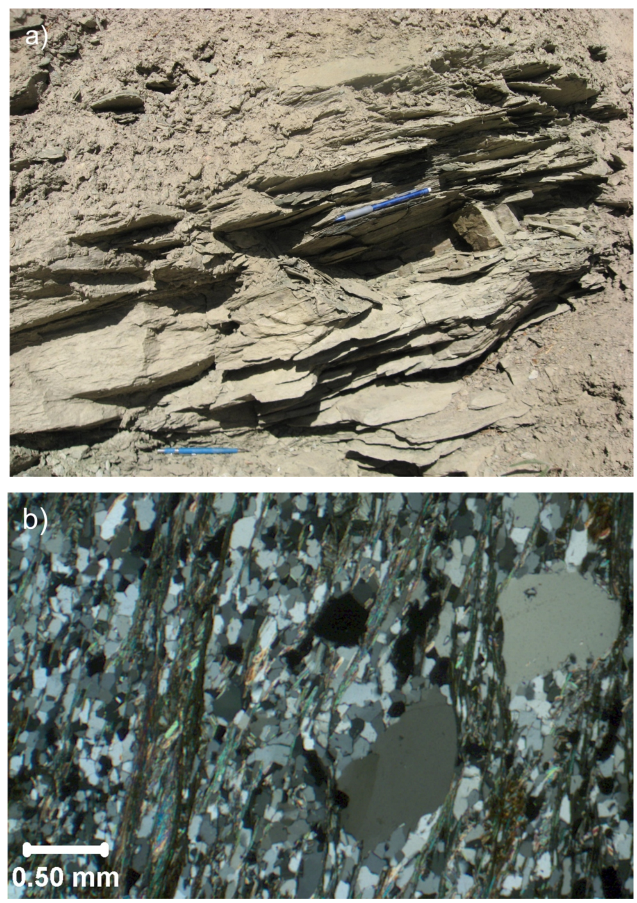


Figure 9. Structural features of the Eastlake–Whipsaw metamorphic belt, southern British Columbia: **a)** outcrop photo of acutely intersecting schistosities in muscovite quartzite (field station 09THS03-01, UTM Zone10, 5444706N, 676242E, NAD 83); **b)** thin-section photomicrograph of a crenulation cleavage in a chlorite quartz-schist (field station 08SOL24-02, UTM Zone 10, 5445666N, 673032E, NAD 83).

Many samples rich in quartz have undergone grain reduction due to grain boundary migration. Even larger relict quartz porphyroclasts will have recrystallized into several smaller grains, blurring or removing any primary textures. Plagioclase porphyroclasts often have minor strain shadows on their edges, but have not formed new grains within their original margins. However, they do have some deformation textures in the form of subgrain boundary rotation and sometimes microfaults, forming domino-type fragments (for further reading on domino-type fragments, see Passchier and Trouw, 2005). Sometimes the porphyroclasts are slightly rectangular and occur obliquely to the direction in which the foliation is aligned, causing the mantled minerals to develop what appears to be opposite shear senses (Figure 10).

Finer grained matrix material includes quartz and feldspar that have undergone recrystallization, which causes the two minerals not only to be fine grained, but also similar in appearance and difficult to distinguish from one another. The rock types containing higher amounts of grain-size reduction are consistently the rock types with the highest ratio of feldspathic material in them.

There has been some brittle failure noted in a chlorite quartz-schist sample collected on Highway 3, in a location adjacent to the Similkameen Falls fault. In thin section, the sample has a milled texture, with all grains, including porphyroclasts, being well-rounded and quite small. The fine-grained matrix has calcite veining, higher amounts of interstitial calcite and significant anhedral oxide material. It seems likely that movement on the fault is milling material in the schist, breaking down the softer mica. The fault could also be acting as a conduit for carbonate-bearing fluids, altering and veining the wallrock.

A third deformation structure, as yet only observed in the field, is visible in certain rock types, in particular a metachert (UTM Zone 10, 5447048N, 674136E, NAD 83). The fold itself is an open fold that maintains constant bed thickness throughout the bend. Striations are seen on the micaceous layers, indicating movement similar to a deck of cards. This style of folding is characteristic of the brittle regime and is thus much different from the other types of strain discussed above, which have all been ductile; this folding style has only been noted in two locations, which may mean it is only a localized event.

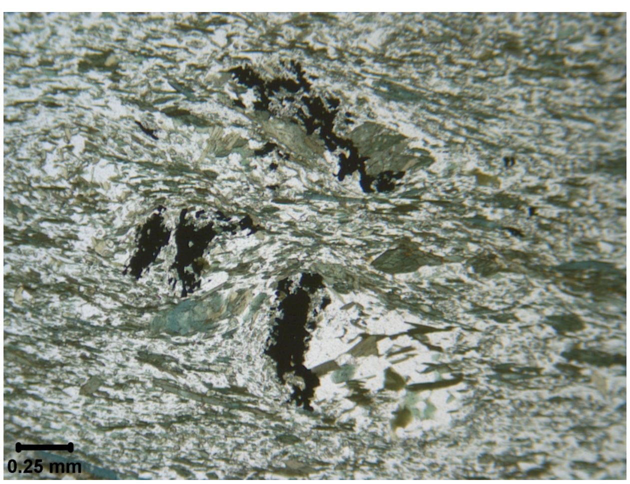


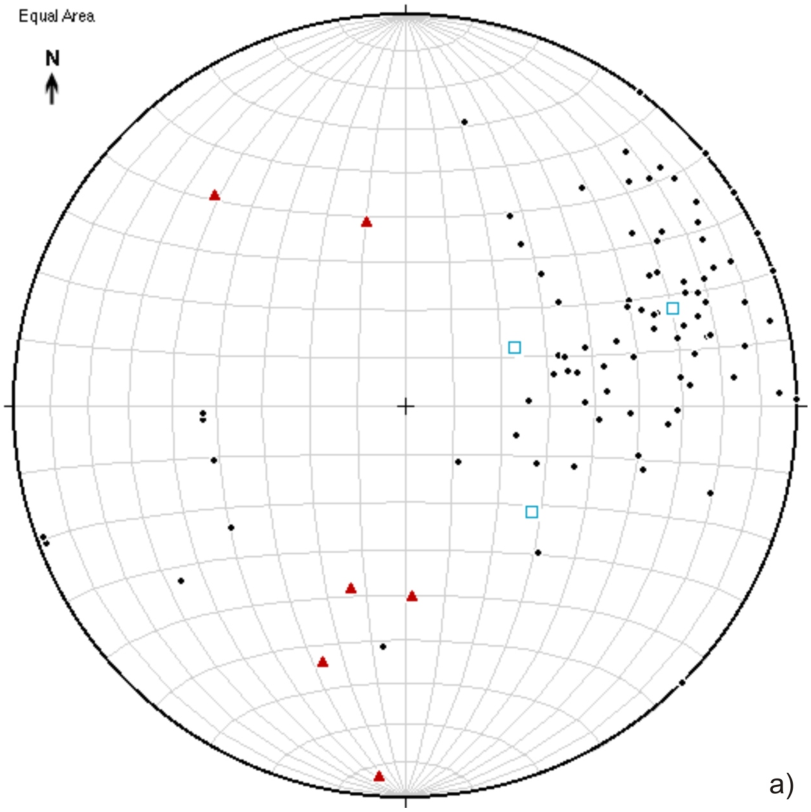
Figure 10. Thin-section photomicrograph of a mantled relict porphyroclasts showing shear textures in an actinolite+chlorite+ feldspar/quartz+biotite schist, Eastlake–Whipsaw metamorphic belt, southern British Columbia (field station 08SOL22-04, UTM Zone 10, 5446268N, 676013E, NAD 83).

Stereonet Projections

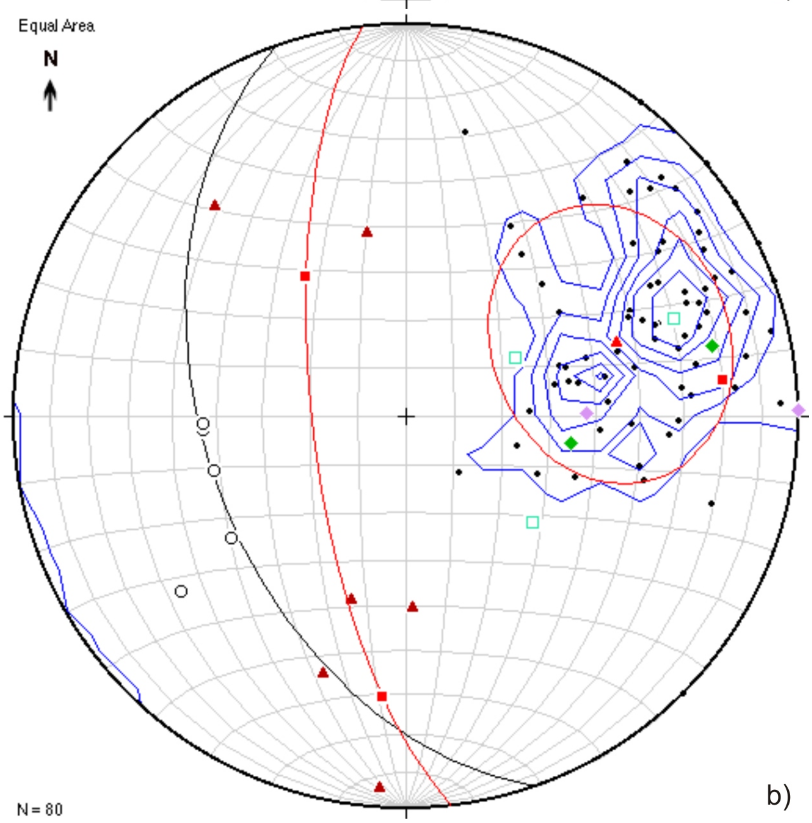
Upon plotting all available structural data measured in the study area, several significant facts can be noted. All foliations and schistosities sit in a single, moderately defined cluster (Figure 11a). In outcrop, there is evidence for two foliations that are further proven through thin section study, showing evidence of crenulation cleavages and two directions of alignment in elongate minerals. However, upon first inspection, there is no obvious distinction between the possible two foliations in the scatter of poles. Since the two foliations strike in similar directions and differ in dip direction mostly, the two clusters would likely overlap, which would make it difficult to extrapolate one from the other. It is worth noting that by using a statistical density contouring analysis on the many pole measurements plotted, two separate clouds are crudely drawn (Figure 11b). In order to truly determine where the separation between the clusters lies on the stereonet projection, many more data points would have to be obtained. The two sets of diamonds (purple and green) are from two separate outcrops where both schistosities were measurable. Both outcrops have the stronger schistosity defined by muscovite and dip more steeply (69–90°). The weaker schistosity was shallower for both (35–38°) and defined by chlorite and muscovite. The green diamonds both correlate well with the statistical clusters, each one relating to one of the two clusters. The two purple diamonds, however do not correlate as closely; one purple diamond does plot within the density cluster, while the other lies just outside of the perimeter (Figure 11b). The lineations align well on a plane, but without knowing what surface the lineations were measured on, the two apparent clusters are not easily explained. The bedding orientations sit parallel to the foliations, suggesting that a form of transposition has occurred. Since few of the units seem to have preserved the deformation textures well, further study into microstructures must be undertaken. Minor units have been sampled, which are high in graphite and have preserved all stages of microfolds well. Thin sections of such samples were not prepared in time for this publication, but will be added to the data in the future. It is definitely significant to note that all the measurements do lie on the same strike planes.

SUMMARY

In order to compare variation in the metamorphic grade across the Eastgate–Whipsaw metamorphic belt, the mineralogy of the more mafic units was analyzed to determine what mineral assemblage is stable. According to Spear (1993), the diagnostic greenschist assemblage is made up of chlorite+albite+zoisite+actinolite+quartz+ carbonate+titanite, while the diagnostic amphibolite assemblage is made up of hornblende+plagioclase±quartz± ilmenite. The metamorphic mineralogy observed in samples across the belt is generally consistent with the epidote–actinolite grade. A more detailed study will be undertaken using the scanning electron microscope to better understand the variations in the solid solutions and link those compositions to more specific pressures and temperatures.



a)



b)

Figure 11. Stereonet projections of structural data from the Eastgate–Whipsaw metamorphic belt, southern British Columbia: **a)** all structural data: black dot, pole to foliation/schistosity; empty green squares, pole to bedding; red triangle, lineation; **b)** statistical contouring: blue contours, 1% density contours; empty blue squares, pole to bedding; red triangle, average pole to foliation/schistosity; empty black circle, cleavage; red square and great circle, average great circle and pole of lineation; black great circle, plane to average foliation/schistosity pole; green and purple diamonds, two schistosities measured at same outcrop (field station 08SOL11-03, UTM Zone 10, 5446508N, 675562E, NAD 83 and field station 08SOL11-10, UTM Zone 10, 5446401N, 675934E, NAD 83).

The main compositional trend is noted in the quartzite belt. This trend goes from west to east and undergoes an addition of calcium and a decrease in potassium in the mineral phases.

The belt has undergone at least three different stages of deformation, culminating in crenulated cleavages and then even-layered folding, which must have occurred at shallow depths later in the deformation history since it overprints the foliations.

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