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Atlin TGI, Part IV: Middle Jurassic Granitic Plutons Within the Cache Creek Terrane and their Aureoles: Implications for Terrane Emplacement and Deformation

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INTRODUCTION

The timing of oceanic terrane obduction within orogenic belts provides important constraints in the evolution of convergent-plate margins. Middle Jurassic plutons, which intrude Cache Creek Terrane in northwestern British Columbia, provide a means to tightly constrain the timing of obduction and the nature of post obduction deformation.

Blueschist ages ($^{40}Ar/^{39}Ar$) from the French Ranges in northwestern British Columbia (Figure 1) indicate that the Atlin complex within the Cache Creek terrane was subjected to blueschist grade metamorphism around 173.2±7.6 Ma (Mihalynuk *et al.*, 1999). The youngest chert, dated by radiolarians from the Atlin complex, indicates an age of between 192+3.8/-5.2 Ma and 178+1.0/-1.5Ma (Cordey *et al.,* 1987; Cordey *et al.,* 1991; Cordey, 1998). These dates, together with isotopic ages, best constrain the timing of obduction of Cache Creek terrane to be between 183-171Ma (Mihalynuk, *et al.*, 1992, 1999).

Crosscutting plutons within the Atlin complex have been dated using reliable methods such as U-Pb zircon and $^{40}Ar/^{39}Ar$ of hornblende and biotite. An example of this is the Fourth of July batholith, which crystallized at 171.7±3Ma (U-Pb; Mihalynuk *et al*, 1992) or 172.7±0.7 Ma from hornblende ($^{40}Ar/^{39}Ar$; Symons *et al.*, 1998). This batholith intruded and thermally metamorphosed the deformed rocks of the Cache Creek terrane and has itself only been subjected to relatively minor, brittle deformation (Mihalynuk *et al.*, 1992). The age of this intrusion, and others within the terrane, constrain the youngest date of Cache Creek terrane obduction to within 9.8 m.y. of crystallization of the Fourth of July batholith (although a compilation of new isotopic data requires obduction within 2.5 m.y. of

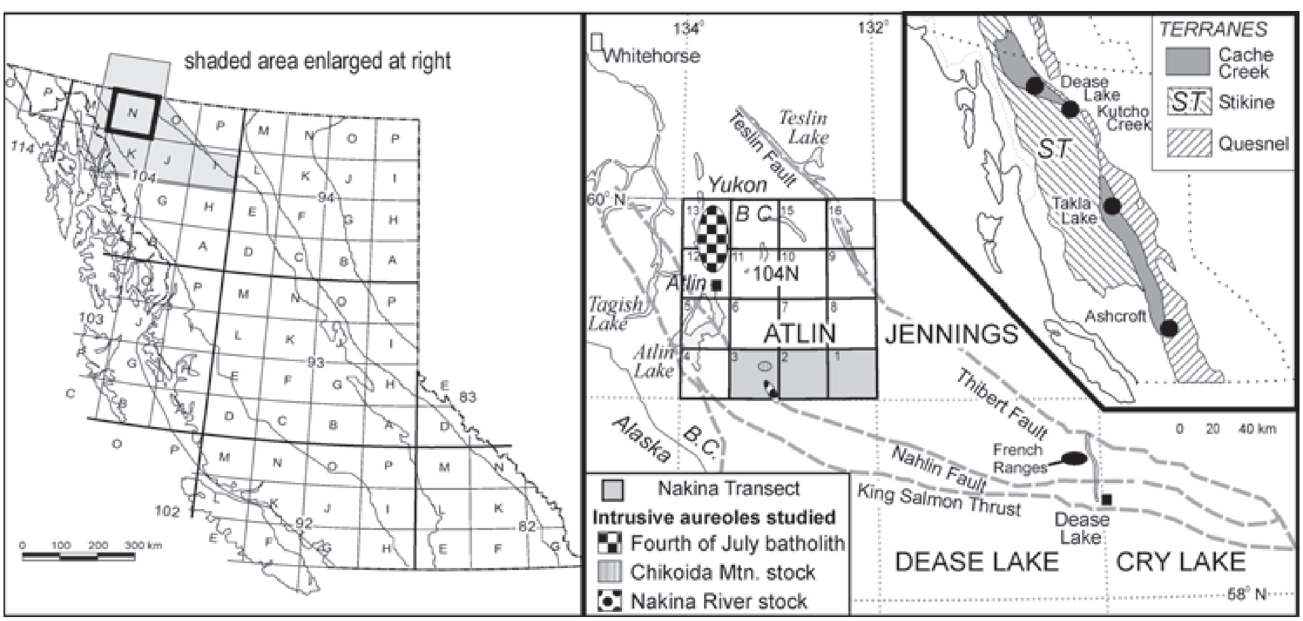

Figure 1. Study area within the northern Cache Creek Terrane, also referred to as the Atlin Complex. The top right hand insert shows adjacent terranes Stikina (ST) to the west and Quesnel (QN) to the east. These three terranes together make up the Intermontane Superterrane. All studied intrusive bodies are within the Atlin map area (104N), while the study area used by Mihalynuk (1998) to date blueschist is further to the southeast in the French Ranges.

intrusion; Mihalynuk, pers. comm., 2002). This paper presents field and petrographic observations from three intrusions of known or suspect Middle Jurassic age (Aitken, 1959; Mihalynuk *et al.*, 2003 (this volume); Figure 1) and their thermally metamorphic aureoles, which overprint the deformed Atlin complex. Detailed petrographic observations provide a test for the relative timing of regional deformation and Middle Jurassic intrusion. Studied intrusive bodies include: Fourth of July (Creek) batholith, Nakina River, and Chikoida Mountain stocks. All intrusive bodies are exposed within the Atlin map area (104N) and their relative locations are shown on Figure 1.

FOURTH OF JULY BATHOLITH

The Fourth of July batholith is a heterogenous intrusive complex, which varies from diorite to granite and alaskite (Mihalynuk *et al.,* 1992). The batholith occupies more than 770 square kilometres in 104N; Aitken, 1959) and is dominantly granite, with biotite- to hornblende-rich and K-feldspar megacrystic to equigranular phases (Mihalynuk *et al.,* 1992). A well-exposed contact along the Atlin Road (Highway 7) south of Como Lake, is the southern most extent of the batholith (Figure 2). At that location the body is a K-feldspar megacrystic hornblende granite. A lateral variation in K-feldspar abundance is common and the rock ranges from that of a sparse to a crowded porphyry. Mafic xenoliths are rare. Euhedral K-feldspar phenocrysts range in size from 1-4cm and typical grain size of groundmass is 2-4mm. No preferred orientation of K-feldspar phenocrysts or xenoliths was observed. Anhedral quartz grains within the groundmass are unstrained, and exhibit little to no undulatory extinction. Common accessory phases include titanite and apatite.

Wallrock metabasites consist of amphibole, plagioclase, quartz and chlorite. Calcite exists predominantly as veinlets 0.05mm wide. Grain size is 0.05 to 1 mm, and no preferred orientation of grains is evident. Many of the quartz grains display undulatory extinction. However, grain boundaries have sharp, straight contacts and quartz grains intersect with 120 degree junctions. The contact between the intrusive and wall rocks is vertical, trending 040 degrees.

Metachert, which has been thermally altered by the batholith, is exposed 100m south of the contact. Minerals include quartz, tremolite and calcite. Grain size is between 0.02 to 0.5 mm. Tremolite grains are acicular and have no preferred orientation. Anhedral quartz grains have undulatory extinction and grain boundaries are serrated. Bedding is sub-vertical, striking 040 degrees. Metacherts, 150m away from the contact, are also thermally altered, but are less so than those at 100metres distance.

CHIKOIDA MOUNTAIN STOCK

The Chikoida Mountain stock is semicircular and relatively homogeneous in mineralogy and grain size. The stock occupies more than 36 square kilometres and is composed of quartz, K-feldspar, plagioclase, biotite and hornblende. Two areas of the stock were studied, including both the southern and northern contacts (Figure 3). The

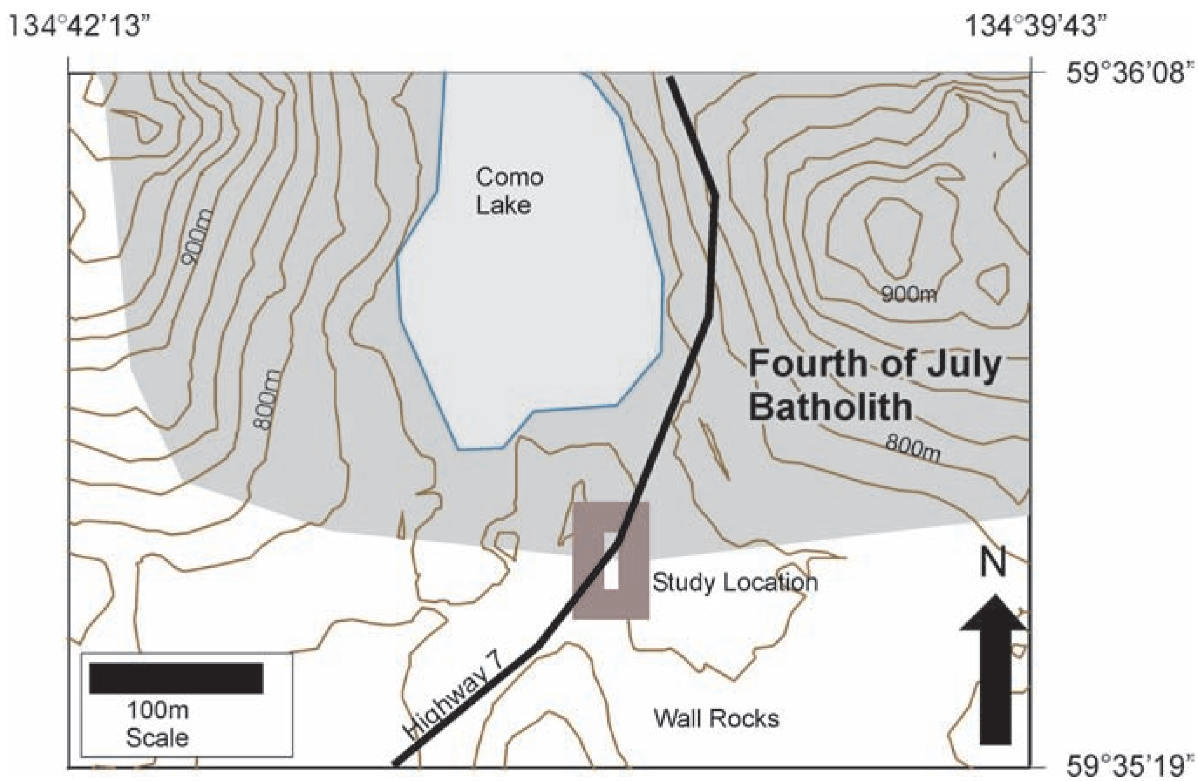

Figure 2. Studied location for the Fourth of July Batholith.

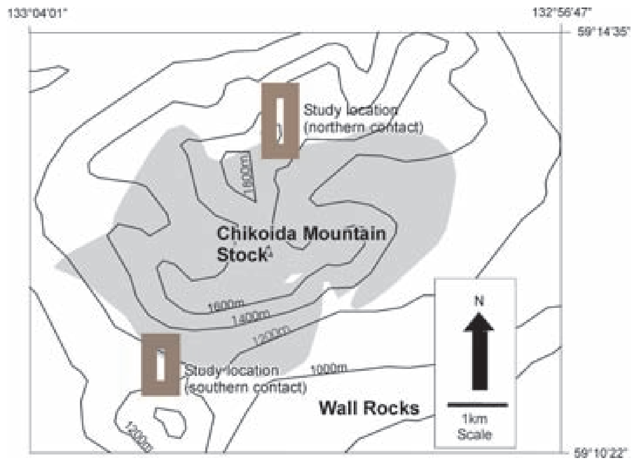

Figure 3. Studied areas of the Chikoida Mountain stock.

rock type at both contacts is hornblende biotite granodiorite. Grain size ranges between 1-4 mm. Both plagioclase and K-feldspar grains are subhedral, but other grains are anhedral with no preferred orientation. Quartz grains have little or no undulatory extinction. Alteration of hornblende to chlorite and alteration of plagioclase to sericite is evident. Accessory phases include zircon and apatite.

NORTHERN AUREOLE

Metapelites at the northern contact are characterized by biotite, quartz, muscovite, sericite, apatite and zircon. Biotite grains have a preferred orientation, while quartz grains have more equant shapes. Quartz grains overprint foliation, which indicates hornfels postdate regional metamorphism (Photo 1). Grain size is 0.1-0.3 mm and grain boundaries are straight to embayed. Quartz grains are not strained. Bedding and foliated fabric are sub-parallel and vertical trending 100 degrees, while the contact is 080/90. Hornfels texture becomes difficult to detect more than 100m from the contact. Regionally metamorphosed volcanoclastics, about 400m from contact, contain strained quartz.

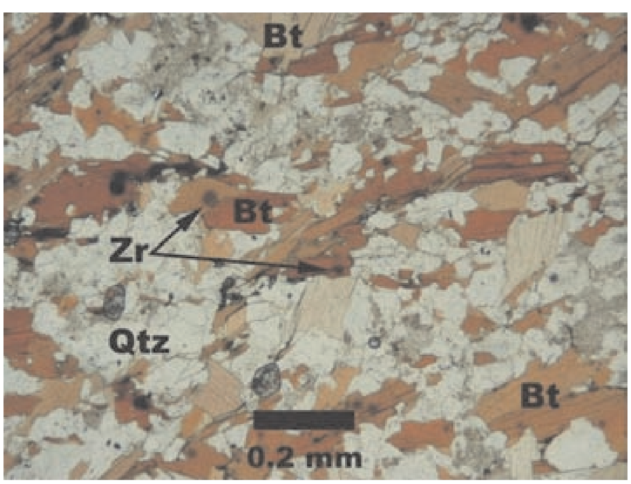

Photo 1. Thin section of hornfelsed metapelite under plane polarized light. This sample was taken within one meter of the contact on the nothern side of the Chickoida pluton. Note that the hornfels fabric is outlined by biotite.

SOUTHERN AUREOLE

Recrystallised calcite (100%) occures within 100 metres of the southern contact of the Chikoida Mountain stock. Calcium carbonate grain boundaries are sharp and intersect at 120-degree junctions. Grain sizes are 0.1-2mm. Pervasive dark and light banding which has a thickness of 4-5mm is orientated parallel to the inferred contact at 090/90. Carbonate rocks 300m farther south are not recrystallised and fossil debris is preserved.

NAKINA RIVER STOCK

The Nakina River stock is an elongated body (trending NW-SE) comprised of two intrusive rock types. It occupies over 97 square kilometres within the 104N mapsheet and is characterized by an inner granodiorite main body with a 200m thick quartz diorite outer rim. The stock is composed of quartz, plagioclase, K-feldspar, biotite, and hornblende, as well as minor epidote. Contacts of the Nakina River stock were investigated at three localities: one on the east side of the body at the southern limit of the Atlin map sheet, and two localities at the northern contacts west of Focus Mountain (Figure 4). The main intrusive body is a homogenous hornblende-biotite granodiorite with grain sizes of 1-3mm, and the outer rim is a relatively finer grained (0.5-2mm) hornblende-biotite-quartz diorite. Both rock types consist of subhedral zoned plagioclase grains, while other grains are typically anhedral. Quartz diorite rocks have sericite-altered plagioclase grains, as well as hornblende altered to chlorite. Granodiorite rocks are typically less altered. A weakly foliated hornblende fabric parallel to the contact is evident in quartz diorite rocks at the northwestern contact. Foliation does not occur in the main inner zone or at the southeastern contact. Strained quartz is present in the quartz diorite rocks at the southwestern contact. Intrusive rocks at the northern margin contain little or no strained quartz. Accessory phases in all rock types include zircon and apatite.

SOUTHEASTERN AUREOLE

Metachert occurs along the southeastern contact. Grains consist dominantly of quartz with fine muscovite inclusions. Quartz grains are 0.05-1mm and have embayed grain boundaries. Undulatory extinction is not evident. Quartz grains are finer in size away from the contact, to <0.01mm at 50 metres. A metamorphosed, quartz diorite dike which has a grain size of 0.1-1mm, occurs 150 metres from the contact. Quartz grains within the dike have undulatory extinction, but no alignment of hornblende or preferred orientation of biotite is evident. A limestone body lo-

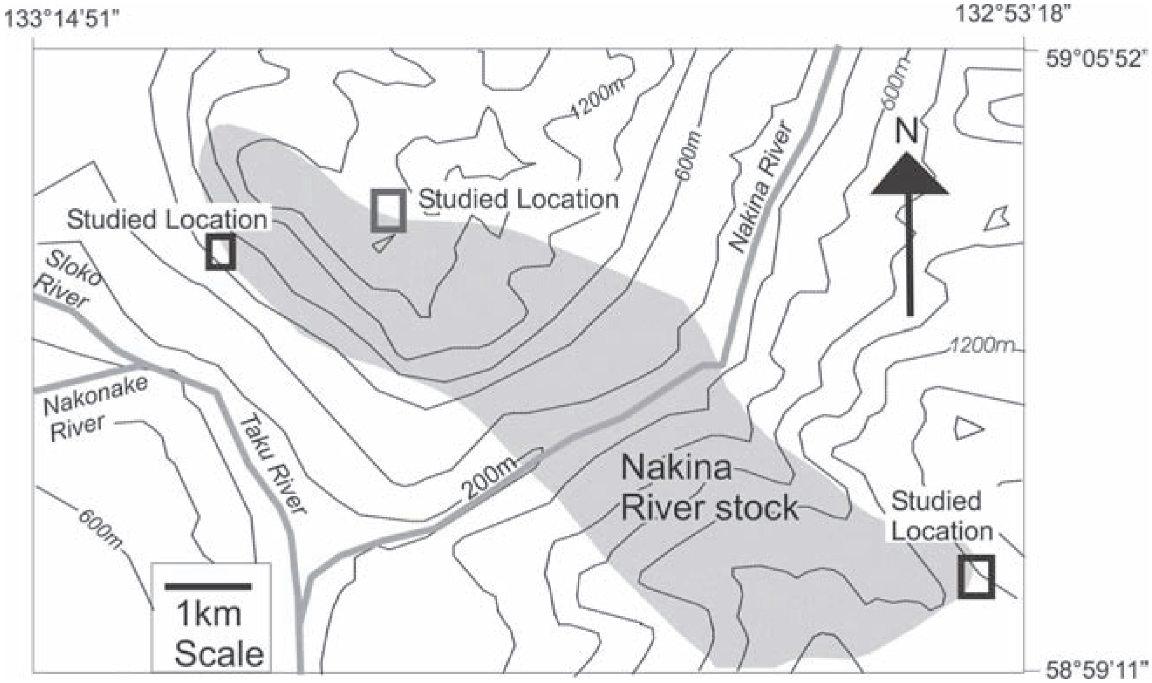

Figure 4. Areas studied at the margin of the Nakina River stock and its thermal aureole.

cated approximately 300m from the contact is fine-grained with little evidence of recrystallisation.

NORTHWESTERN AUREOLE

Metabasite rocks exposed at the northwestern contact are characterized by amphibole, quartz, plagioclase and biotite. Grains are 0.05-1mm with sharp, straight grain boundaries. Biotite is kinked and quartz displays undulatory extinction. Alignment of amphibole grains defines a foliation. Aligned biotite inclusions, within amphibole, may define a pre-existing fabric at a high angle to the fabric defined by amphibole alignment (Photo 2). Late biotite is orientated 90 degrees to hornblende and reflects a shift in direction of the major stress field. Delta-type amphibole porphyroclasts indicate a dextral vorticity (Photo 3). Foliation is orientated sub vertical with a trend of 140 degrees and is sub parallel to the intrusive contact, which is vertical, trending 135 degrees.

Northern Aureole

Like the northwestern aureole, metabasite includes quartz, amphibole and biotite. Grain size is very fine (0.01-0.05mm) and amphibole grains are well aligned. Stress kinking and mild undulatory extinction is observed in biotite and quartz respectively. Grain boundaries are

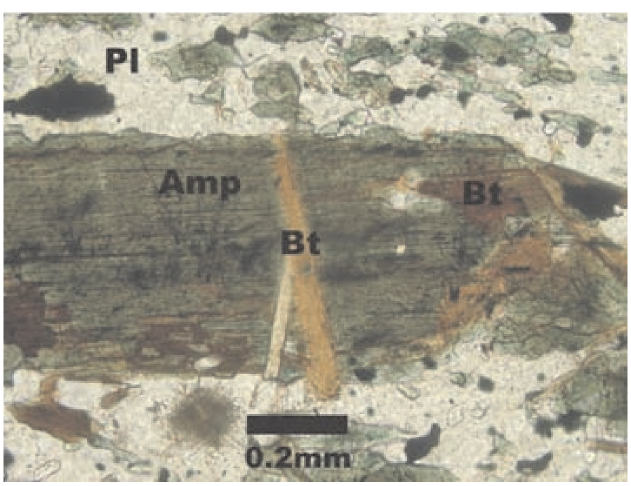

Photo 2. Thin section of a metabasite under plane polarized light. This sample was taken from within one meter of the contact on the south eastern side of the Nakina River stock. Note that amphibole grains have overgrown biotite which is typically orientated with its long axis 90 degrees to the dominant foliation.

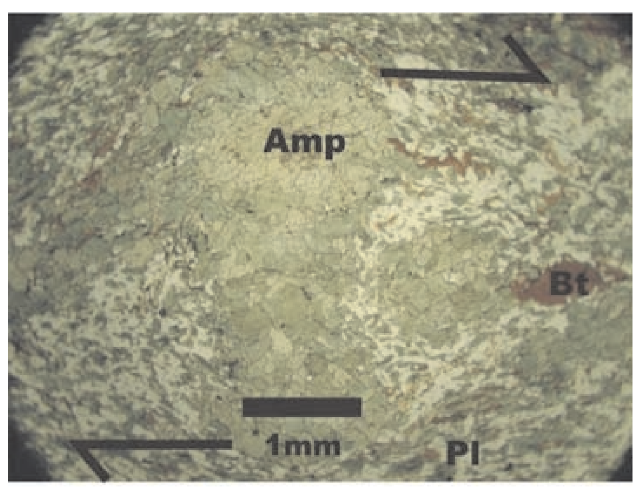

Photo 3. Thin section of metabasite under plane polarized light. This sample was taken from within one meter of the contact on the southwestern side of Nakina River stock. Hornblende porphyroblast is delta-form, indicating dextral vorticity (arrows).

sharp and straight. Quartz grains intersect at 120-degree junctions.

DISCUSSION AND CONCLUSIONS

Features common to all of the intrusions and intrusive aureoles investigated indicate that ductile deformation, during or following pluton emplacement was not significant. These features include: a general increase in the frequency of stressed minerals away from intrusive contacts; a lack of foliation in intrusive rocks, and the presence of hornfels texture overprinting foliation in aureole rocks. In addition, a smooth annular aeromagnetic anomaly within the Chikoida Mtn. stock, and magnetic contact aureoles around semicircular bodies, such as Mount McMaster, appear undeformed. Minor, brittle faulting is common near the contacts of most bodies, but nowhere is a fault offset of an aureole identified, nor has folding of a contact aureole been observed.

One exception may be the northwestern contact of the Nakina River stock where delta-type porphroclasts (Photo 3) and the presence of an internal fabric outlined by biotite within amphibole porphyroblasts (Photo 2) indicates deformation along the southwestern margin occurred during emplacement. Orientation of delta-type porphyroclasts implies subvertical dextral shear subparallel to the intrusion margin. This fabric could be related to regional stresses or, more likely, to local stresses attending magma emplacement. Intrusion-generated fabrics are shown by Aitken (1959) to be a common feature of Middle Jurassic intrusions. The common occurrence of biotite grains that define an overprinting fabric perpendicular to an earlier, growth-defined fabric of amphibole (Photo 2) may indicate a transient stress field that switches abruptly during retrograde metamorphism related to cooling of the intrusion. The data suggest a principle stress that changes from a sub-horizontal to a sub-vertical orientation. Systematic study of cooling ages from amphibole and biotite grains, which define fabric in aureoles, should be conducted to help to better define the history of deformation within Cache Creek rocks.

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