British Columbia Geological Survey
Geological Fieldwork 2002

Atlin TGI, Part I: Atlin Targeted Geoscience Initiative - Summary of Accomplishments and Project Closure

By Mitchell G. Mihalynuk[1] and Carmel Lowe[2]

KEYWORDS: Geology, aeromagnetic survey, mineral potential, hydrocarbon, organic maturation, coal, volcanogenic massive sulphide, pluton related gold, geochemistry, fossil, geochronology, Cache Creek Terrane, Atlin, Nakina.

INTRODUCTION

A third and final season of geoscience field studies under the aegis of the Targeted Geoscience Initiative (TGI) was completed in the Atlin area in 2002. Jointly funded by the federal and provincial governments, the TGI is designed to deliver timely, high-quality geoscience data as a lasting stimulus for mineral resource exploration and economic development. The Atlin region was selected from other national proposals for three pincipal reasons: the regional economy is mineral resource dependent, with a single commodity focus on placer gold; the existing regional geological framework predates plate tectonic theory; and the area is well endowed with geological environments prospective for other types of mineral deposits.

TGI geoscience data collection began in 2000 with a federally funded, high-resolution aeromagnetic survey covering the entire project area (NTS 104N; Figure 1). Joint federal and provincially supported mapping studies began in 2001. Aided by the aeromagnetic data, mapping provided on-the-ground evaluation of geological environments for their potential to host different deposit types; for example, volcanogenic massive sulphide accumulations. Proof of concept is in the discovery of a magnetite exhalite in 2001, and in 2002, semi-massive pyrite-chalcopyrite lenses (*see* Joss'alun occurrence in TGI, Part III, this volume).

[1]*BC Geological Survey Branch*
Mitch.Mihalynuk@gems5.gov.bc.ca
[2]*Geological Survey of Canada, Sidney, BC*

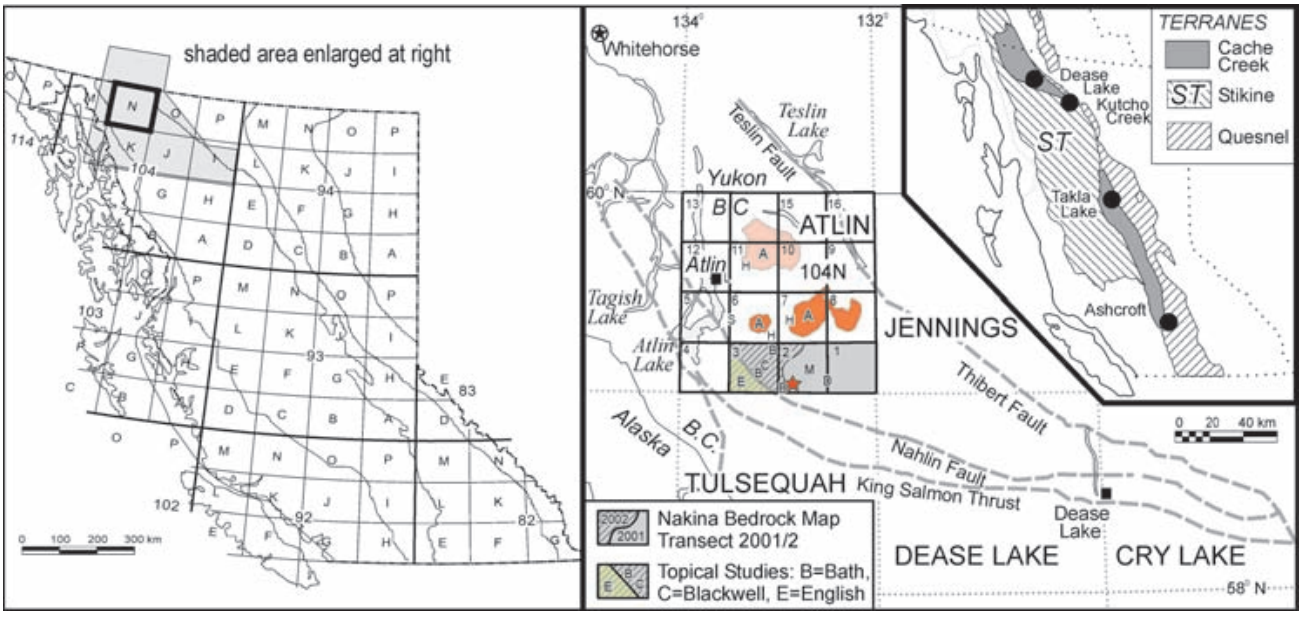

Figure 1. Location of the Atlin Integrated Geoscience Project in northwestern British Columbia. Bold outlined box (104N) shows extent of aeromagnetic survey. Regional geological mapping surveys were conducted over the eastern and central Nakina transect (104N/1, 2) in 2001 and extended into 104N/3 in 2002. Reconnaissance plutonic studies covered parts of 104N/6, 7, 8 and 10 in 2001 and 104N/10 and 11 in 2002, denoted by A (plutons shaded). Locations of local topical studies, including theses, are shown by: A. Bath *et al.* (2003, this volume); C. Blackwell/Roenitz ; D. Devine (2002); E. (shaded), English, *et al.* (2003, this volume); H. Harder; L. Hansen; M. Merran; S. Sano *et al.* (2003, this volume). Star denotes approximate location of Joss'alun discovery in southwest 104N/2.

TABLE 1
PRODUCTS DELIVERED AND PLANNED AS PART OF THE ATLIN TGI

Person(s)	Affiliation	Product(s)	Status
Dumont, R., Coyle, M. and Potvin, J.	GSC Ottawa	16 - 1:50 000 sheets; *e.g.* Dumont *et al.* (2001a, b, c)	Complete
C. Lowe	GSC Pacific	Magnetic modelling	*see* Lowe and Anderson (2002)
C. Lowe	GSC Pacific	Thematic map(s)	in preparation
M. Mihalynuk, S. Johnston, J. English, F. Cordey, F. Devine, Y. Merran, A. Bath, K. Larson, O. Roenitz, L. Leonard	BCMEM, UVic, UCB, UBC, SFU	1:50 000 sheets: 104N/1, 2 and 3	Compilation complete;104N1&2 sheduled for release in early 2003
R. Anderson	GSC Vancouver	Input for magnetic modelling, topical report(s)	Samples in preparation
F. Cordey (2001, 2002)	UCB	Fossil age database; approximately 140 age determinations	80 samples for 2001 complete (*see* Mihalynuk *et al.* , 2002a, 2003b this volume)
M. Orchard	GSC Vancouver	Fossil age database; 25 samples in 2001, 20 samples in 2002	Preliminary report complete: *see* Mihalynuk *et al.* (2003b this volume)
W. Bamber	GSC Calgary	Fossil age database and paleobiogeographical interpretations	Preliminary identifications completed
L. Rui	Paleontological contractor, Calgary	Fossil age database and paleobiogeographical interpretations	56 samples from 2001 identified; *see* Mihalynuk *et al.* (2003b this volume)
Johnston, S.T., Mihalynuk, M. Lowe, C. and Cordey, F.	UVic, BCMEM, GSC, UCB	Four free public lectures in Atlin, summer 2001	Completed
C. Lowe	GSC Vancouver	Free public workshop on application of ground-based magnetic surveys	Completed
Anderson and others	GSC Vancouver	Public information in popular wall poster format	Mock-up complete
J. English	UVic	Ph.D. thesis, presentations and papers	2 papers completed; *see* English *et al* . (2002, 2003 this volume)
Y. Merran	UCB	M.Sc. thesis, presentations and papers	M.Sc. thesis completed and degree granted
F. Devine	UBC	B.Sc. thesis, presentations and paper	B.Sc. thesis completed and degree granted
M. Villeneuve	GSC Ottawa	Geochronological database and topical report(s)	Preliminary age data provided for 6 samples
G. Dipple and student Lyle Hansen	UBC	Reconnaisance in 2001/2	Laboratory work underway
C. Lowe and Mihalynuk, M.; English, J.	GSC, BCGS, Uvic	Oral presentations and posters	2001, 2002 delivered
J. English	Uvic	Poster presentation	2002 delivered
L. Struik, C. Lowe and others	GSC	Poster Presentation of TGI projects in BC	2002 delivered
C. Lowe and others	GSB, BCGS	Oral presentation	2002 delivered.
C. Lowe and others	GSC and others	Oral presentation (Lowe, 2002; Mihalynuk, 2003), 4 poster sessions 2002, 4 poster sessions 2003	2002 delivered; 2003 in preparation

Table 1 continued

Joss'alun discovery	M. Mihalynuk	BCMEM	Oral presentation Vancouver; presentation as Geofile 2002-6	Complete
Carbonate-chert facies, Sentinel Mountain area	H. Sano; T. Igawa; T. Onoe	Kyushu U, Japan	Fossil age database, paper(s)	Preliminary age data presented in Sano *et al.* (2003, this volume)
Atlin placer potential	V. Levson	BCMEM	Surficial geology/placer potential map	Base completed 2001; final in drafting for release in early 2003
AGU conference: Cache Creek volcanics	J. English	Uvic	AGU 2002 poster presentation	in preparation for late 2002
Contact aureoles of Mid Jurassic plutons	A. Bath	UVic	Directed study; paper	*see* Bath, 2003; this volume
Structure of gabbroic allochthon	J. Blackwell	Uvic	B.Sc. thesis, presentations and paper	work in progress
Cache Creek growth and emplacement structures	O. Roenitz	SFU	Directed study; paper	work in progress
Geological compilation Atlin, 104N	M. Mihalynuk, S. Johnston, B. Anderson, C. Lowe, J. English, F. Cordey	BCMEM, UVic, GSC, UCB	1:250K digital map	Preliminary updates completed in 2000, 2002; final anticipated in 2003

Field studies in 2001 and 2002 benefited tremendously from working partnerships. In 2002, these partnerships included: the University of Victoria (S.T. Johnston, J.M. English, J.E. Blackwell, A. Bath); Université Claude Bernard (UCB), Lyon, France (F. Cordey, Y. Merran); Simon Fraser University (O. Roenitz); Kyushu University, Japan (H. Sano, T. Igawa, T. Onoue); Institute of Sedimentary and Petroleum Geology (W. Bamber, L. Rui, M. Fowler); GSC Vancouver and Ottawa (R. Anderson, M. Orchard and M. Villeneuve); and the BC Ministry of Energy and Mines New Ventures Branch (M. Hayes).

This report summarizes major accomplishments of the TGI program and partnerships, products delivered and products forthcoming. Following this summary, are reports by Mihalynuk *et al.* (2003a, this volume) on geological mapping results; Mihalynuk *et al.* (2003b, this volume) on the new Joss'alun discovery; Sano *et al.* (2003, this volume) on carbonate and chert facies and biostratigraphy; Bath (2003, this volume) on Jurassic pluton aureoles and English *et al.* (2003, this volume) on Laberge stratigraphy and hydrocarbon potential.

ACCOMPLISHMENTS

Success of the Atlin TGI can be judged by at least four measures:

- timely publication of results, in both numbers and scope, far exceeding those outlined by the original project proposal;
- support for a number of researchers, their students and theses, exceeding by a factor of two, those anticipated in the original project proposal;
- discovery of mineral occurrences as proof of the underlying concepts and justification for the project;
- geological discoveries that fundamentally change the way in which we view the Cache Creek terrane, its age, its tectonic significance, and its mineral potential.

Rapid publication of data and syntheses are a cornerstone of the Atlin TGI design. An indication of compliance with this design is the fast-growing legacy of the Atlin TGI contributions, as can be seen in Table 1 and the list of References Cited. Already published products include 16 aeromagnetic maps and 12 papers. Numerous technical poster presentations and lectures have also been given. Unpublished TGI results include two theses and three reports on microfossils. Ongoing, are two theses and a directed study funded by TGI, and three additional theses and a post-doctoral study having benefited from logistical support through TGI.

During the founding stages of the initiative, existing geoscience information was compiled for the Atlin 1:250 000 sheet, and presented draped over the shaded relief elevation model. Small-scale geological maps showing TGI field mapping results have been presented in the published papers, but plans call for publication of three 1:50 000 scale geological maps in 2003. During completion of the TGI, a digital version of the updated Atlin area map will be produced for download or manipulation in MapPlace (www.em.gov.bc.ca/geology).

Scheduled delivery of TGI products has been modified from that presented by Mihalynuk and Lowe (2002), principally due to an in depth fiscal review and funding clawbacks by the Provincial Government. During this review, Ministry of Energy and Mines participation in the Atlin TGI was temporarily derailed. Participation in the Atlin TGI was restored just before the field season, but with a reduced budget. Nevertheless, about 90% of the transect mapping originally planned has been completed.

Provincial funding had less impact on portions of the program that relied only on federal funding. Carmel Lowe continued to synthesize and model the aeromagnetic data set collected in 2000 and 2001, and Bob Anderson conducted a field evaluation of magmatic bodies with more than 40 traverses.

MAP COVERAGE AND HIGHLIGHTS

A second season of mapping the Nakina Transect (104N/1, 2 & 3) permitted complete coverage of Mapsheet 104N/2 and about 75% of 104N/3 (Figure 2). Incomplete areas include the river valleys of the Nakonake; the Nakina, below its confluence with the Silver Salmon River; and the Sloko, downstream of the Nakonake River. Incomplete coverage also exists in lower Goldbottom Creek (above and below "Psychobear Ridge", note that informal names appear in quotes), the western slopes of Chikoida Mountain, and the alpine area west of an unnamed peak in southwest 104N/2.

Highlights of the mapping and preliminary analysis of samples include:

- discovery of massive sulphide mineralization at the Joss'alun occurrence. Apparently stratiform sulphide lenses occur within a pillow basalt succession that is interbedded with Permian chert along strike and overlain by a coarse clastic unit containing chert breccia fragments of Middle Triassic age and sandstone containing Permian zircons (Mihalynuk *et al.*, 2003b; Figure 2, star).
- an increase in the width of the serpentinite melange belt extending it to the northeast, almost as far as the Silver Salmon River (Figure 2 diagonal hatch west of Silver Salmon River).
- recognition of intense thrust repetition of strata in the canyons walls of Taysen Creek, "Tumblepack Creek" and Nakina River of northeast 104N/2W (Figure 2, highlighted creek sections).
- discovery of a broad zone of quartz-sericite-pyrite alteration in siliceous argillaceous strata exposed along upper "Tumblepack Creek" (Figure 2, solid box).
- preliminary hydrocarbon assessment of the southern Whitehorse Trough (English *et al.*, 2003, this volume).
- recognition of a magnetic unit within the Laberge Group (SI ~15-25 x 10^{-3}). This unit includes several percent orange garnet as well as sparse, fresh olivine crystals. It may record exposure of the Cache Creek mantle during Cache Creek emplacement (Figure 2, stippled belt).

Geological setting, stylized stratigraphy, isotopic and micropaleontologic age, and chemical analyses from the Joss'alun occurrence and environs are presented in greater detail in Atlin TGI, Part III (Mihalynuk *et al.*, 2003b, this volume). Details of Nakina Transect mapping results, micropaleontological and isotopic age, and lithogeo chemical and stream sediment data are presented in TGI, Part II (Mihalynuk *et al.*, 2003a, this volume).

MAGNETIC SURVEY STUDIES

Approximately 32 000 line-kilometres of aeromagnetic data covering the entire Atlin 104N mapsheet were collected as part of the regional aeromagnetic survey in 2000 and early 2001 (for survey parameters and details *see* Lowe and Anderson, 2002). Survey results have been published at 1:50 000 scale as a series of sixteen aeromagnetic anomaly maps (Dumont *et al.*, 2001a, b, c and 13 others). The survey benefited from augmentation by magnetic susceptibility measurements taken in the field during the course of geological mapping.

One of the most striking features of the aeromagnetic data set is a strong positive aeromagnetic anomaly that extends far northeast of the previously mapped extent of ultramafic rocks. A two-dimensional model of magnetic data (Lowe *et al.*, 2002a) showed that the observed data could be explained by a series of steeply northeast-dipping, ultra-

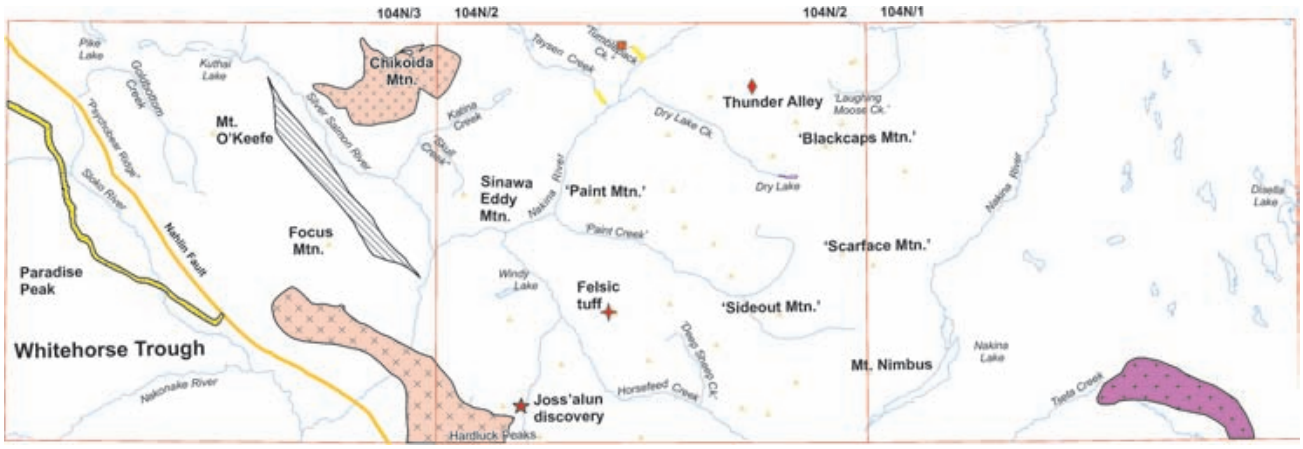

Figure 2. Nakina transect physiographic features, major intrusive bodies (patterned) and serpentinite mélange (diagonal hatch). Symbols show location of mineralized zones.

mafic lenses. Efficacy of modelling was limited by a lack of direct magnetic susceptibility measurements within and adjacent to the ultramafic rocks. To remedy this problem, Lowe and Canil (UVic) sampled and measured magnetic susceptibilities across the Nahlin ultramafic body and adjacent rocks in southwestern 104N/2 (Figure 1). In that area, ultramafic rocks are mainly serpentinized harzburgite, with pods of serpentinized dunite. They demonstrated an expected correlation between magnetic susceptibility and degree of serpentinization. However, the most intense aeromagnetic anomaly values (>2000 nT) correspond with rocks that are only moderately serpentinized at the surface. It would appear that either the ultramafic rocks are more pervasively and intensely serpentinzed at depth, or that ultramafic bodies may persist to depths of >7 km. Lowe is now utilizing the new *in situ* susceptibility measurements in constructing a more detailed model to explain the airborne anomalies. New map data also will bear on the model because we now know that ultramafite *DOES* extend farther to the northeast as a series of serpentinite melange belts (Figure 2, hatched area west of Silver Salmon River).

JURASSIC AND CRETACEOUS PLUTONIC ROCKS

Granitiod batholiths and stocks of Jurassic and Cretaceous age are widespread in the Atlin area (Figure 1, shaded). Middle Jurassic bodies are temporally and spatially associated with known lode gold veins (Ash, 2001). According to Ash, the veins are usually near the Middle Jurassic stocks or other high- level intrusions assumed to be comagmatic, but hosted by oceanic crustal rocks, mainly gabbro and diabase, of the Cache Creek terrane. This association is mimicked by regional geochemical stream sediment gold values: most Atlin mapsheet samples that are 90th percentile and above (, are from streams that drain the margins of Middle Jurassic plutons. Despite these encouraging geologic and geochemical relationships, no significant past production (in excess of 1 kg) has been recorded from any gold lode vein discovered thus far in the Atlin camp.

Enrichments of uranium, molybdenum, tin, tungsten, beryllium, fluorine and other granophile elements are typical of the Surprise Lake batholith. Molybdenum in particular, is enriched in a part of the Batholith called the “Mount Leonard Boss” stock (*e.g.* Christopher and Pinsent, 1982). The stock underlies the headwaters of Ruby Creek from which placer gold is recovered (Figure 1); near ‘H’ in 104N/11.

In 2002, R. Anderson built upon a 2001 reconnaissance study of Middle Jurassic and Cretaceous plutonic bodies (Lowe and Anderson, 2002). Objectives of the study are:

- to map compositional heterogeneity;
- correlate composition with magnetic signature;
- establish timing of different phases;
- look at contacts with deformed Cache Creek country rocks;
- look for alteration and evidence for late-stage magmatic volatiles;
- evaluate their potential for enrichments in gold and granophile elements. In particular, scrutinize plutons where they underlie the headwaters of creeks from which gold placers are won, or from which anomalously high base or precious metal values have been recorded in stream sediment samples.

Work on pluonic rocks was about equally divided between presumed Middle Jurassic bodies originally mapped and named by Aitken (1959) as Mount Llangorse batholith and Mount McMaster stock, and the Surprise Lake batholith of Late Cretaceous age (Christopher and Pinsent, 1982; Mihalynuk *et al.*, 1992).

Modal analyses of the Mount Llangorse batholith by Aitken (1959) show it to be mainly diorite and tonalite. According to Aitken, the core is more felsic than the rim, consistent with a coreward decrease in the aeromagnetic response. Aitken also showed that the country rocks having been shouldered aside by the batholith producing a foliation within the batholith and within the adjacent 1.2km-wide thermal aureole.

Mount McMaster stock (Aitken, 1959) is a composite of irregularly distributed quartz monzodiorite and hornblende-biotite granodiorite and monzogranite. It is unfoliated and more felsic and leucocratic than the Mount Llangorse batholith. Miarolitic cavities occur along one contact. The nearly circular outline of this stock is mimicked by an annular aeromagnetic anomaly.

Surprise Lake batholith is compositionally homogeneous, especially when contrasted with its high degree of textural variability. Overall, it is biotite granite with numerous local concentrations of uranium and other granophile elements (Cu, Zn, Mo, Sn, W). It is the best studied of all intrusions in the Atlin area, due to numerous contained mineral occurrences, including the Adanac molybdenum deposit. Mineralization at Adanac occurs in several phases of the “Mount Leonard Boss” stock, which is separated from the main batholith by a belt of country rocks on its eastern side. Defined, open pit-able reserves at the Adanac deposit are 152 million tonnes grading 0.063% Mo (Christopher and Pinsent, 1982). Most mineralization is associated with porphyritic or megacrystic phases. Miarolitic cavities up to decimetre size are common in scattered zones. Cavities are lined with alkali feldspar, smokey quartz and tourmaline. These features record late vapour phase evolution during high-level emplacement.

Most of the Surprise Lake batholith is characterized by magnetic susceptibility values less than 0.1 x 10-3 SI and correspondingly low magnetic anomaly values. However, a series of northwest-trending magnetic lineaments with peak amplitudes of 20-30 nT is imaged over the eastern portion of the batholith and adjacent aureole (Lowe and Anderson, 2002).

SURFICIAL GEOLOGY AND PLACER POTENTIAL

Despite a focus on geological environments other than placer gold, the TGI program also serviced this mainstay of the Atlin economy. An enhanced surficial geology map of the Atlin mining district was produced on a digital elevation base. It will be formally published in early 2003, together with placer potential information as Levson *et al.* (2003). The map is an updated, coloured and visually enhanced version of an earlier publication by Levson and Kerr (1992). Updates include recent research on the Quaternary geology of the area (Levson and Blyth, 2001); new field and geochemical data bearing on platinum in placer deposits (Levson *et al.*, 2002); and revised map units together with chrono-stratigraphic and surficial materials data. Marginal notes discuss placer gold potential of both buried-channel and Holocene deposits, as well as potential of the bedrock to supply gold for placers.

UNIVERSITY THESIS STUDIES

One measure of Atlin TGI success is the high proportion of student geoscientists who, through the initiative, have pursued theses or directed studies on geological aspects of the Atlin area. Seven of the eight student members of 2001/2002-field mapping crews completed, or are currently working on, advanced study topics under the auspices of the Atlin TGI.

Two thesis studies begun in 2001 were completed in 2002. Y. Merran completed his M.Sc. thesis, supervised by F. Cordey at Université Claude Bernard, entitled Mise en Place et Environnement de depot d'une Plate-Forme Carbonatee Intraoceanique: Exemple du Complexe d'Atlin, Canada (Merran, 2002). Under the supervision of J.Mortensen at The University of British Columbia, F. Devine completed her B.Sc. thesis entitled "U-Pb geochronology, geochemistry and tectonic implications of oceanic rocks in the northern Cache Creek terrane, Nakina area, Northwestern British Columbia" (Devine, 2002). J. English began work on a M.Sc. study in 2001 under supervision of S. Johnston at the University of Victoria. His study of volcanic environments and petrogenesis, has evolved into one component of a Ph.D. on the evolution of the Whitehorse Trough and evaluation of its hydrocarbon potential. Also under the supervision of S.Johnston at the University of Victoria, is a B.Sc. thesis on the structural setting of a gabbro allochthon by J. Blackwell, and a directed study on characterization of aureoles around Middle Jurassic plutons by A. Bath. A Ph.D. thesis study supervised by D. Canil at the University of Victoria, was to compare Cordilleran ultramafites, including the bodies near Atlin. Unfortunately, it has been suspended and Canil is synthesizing the Atlin data collected thus far.

Atlin TGI also supports components of post-doctoral study by T. Igawa and a Ph.D. thesis by T. Onoue, supervised by H. Sano, Kyushu University, Japan. Logistical support has also been provided for 2 M.Sc. theses at The University of British Columbia. L. Hansen, supervised by G. Dipple, is investigating carbonatized ultramafite as a natural analogue for application in industrial *in situ* CO_2 sequestration. M. Harder, under the supervision of K. Russell, initiated an investigation of erosional remnants of Quaternary diatremes and comagmatic pyroclastic and lava flow successions that pepper the Atlin area. One focus of their study is the use of abundant mantle xenoliths as probes of the subcrustal lithosphere (*see* Lowe *et al.*, 2003 for preliminary findings). Table 1 provides a summary of Atlin TGI participants, their affiliations and products.

PUBLIC OUTREACH

Public outreach is recognized as a key component of the Atlin TGI. A public outreach program in the townsite of Atlin began as a series of free public lectures in 2001. In 2002, C. Lowe continued the program with a workshop on the use of handheld magnetic survey devices for fun and profit. Sshe also presented a poster at the PDAC meeting in Toronto in March, 2002 and gave a seminar on the magnetic component of the project in April. Elsewhere, public presentations have been delivered at six venues within and outside Canada. Continued delivery of project results will be by a combination of public lectures, poster sessions and conventional maps and reports (*see* Table 1). Anderson is currently working on Atlin Geoscape, a wall poster product aimed at public education. Geoscape posters have proven to be a popular teaching tool in schools.

PROJECT WRAP-UP

Atlin TGI funding terminates at the end of the 2002/3 fiscal year, in the spring of 2003. In accordance with the original design of TGI programs, all products are to be delivered by that time. It is apparent, however, that not all project generated data will be available for synthesis in time for the spring deadline. In addition, J. English has plans for fieldwork in 2003, as part of his Ph.D. study. Clearly, the rollout of future TGI-generated products will extend past the spring of 2003, with an impact that lasts well beyond.

ACKNOWLEDGMENTS

Success of the Atlin TGI is attributable to the combined efforts of many contributing geoscientists. In 2002, these were: Joe English, Steve Johnston, Adam Bath, Jacqueline Blackwell, Lucinda Leonard and Dante Canil (UVic); Fabrice Cordey (UCB, Lyon); Bob Anderson, Mike Villeneuve, Mike Orchard, Wayne Bamber and Martin Fowler (GSC); Oliver Roenitz (SFU); Lyle Hansen, Margaret Harder and Kelly Russell (UBC); Hiroyoshi Sano, Toshie Igawa and Tetsuji Onoue (Kyushu University); Fionnuala Devine (YGO), and Paul Wojdak (BC MEM). Jim Monger supplied his original field maps, which helped to direct our work.

Heartfelt thanks are owed to the community of Atlin for their unflagging passion for geoscience. More than any single person, the success of the program hinged on our helicopter pilot, Norm Graham of Discovery Helicopters in

Atlin. We regularly entrusted our lives to Norm, in the face of adverse weather and terrain - and he always delivered.

REFERENCES CITED

Aitken, J.D. (1959): Atlin map-area, British Columbia, *Geological Survey of Canada,* Memoir 307, 89 pp.

Bath, A. (2003): Atlin TGI, Part V: Middle Jurassic granitic plutonswithin the Cache Creek terrane and their aureoles: Implications for emplacement and deformation; *in* Geological Fieldwork 2002, *BC Ministry of Energy and Mines*, Paper 2003-1, this volume.

Christopher, P.A. and Pinsent, R.H. (1982): Geology of the Ruby Creek and Boulder Creek area near Atlin (104N/ 11W); *BC Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map, 52, 10 pages.

Cordey, F. (2001): Preliminary report on radiolarians, August 2001, 3 pages (unpublished report).

Cordey, F. (2002):Report on radiolarians, Atlin, winter 2001-2002, 5 pages (unpublished report).

Devine, F. (2002): U-Pb geochronology, geochemistry and tectonic implications of oceanic rocks in the northern Cache Creek terrane, Nakina area, Northwestern British Columbia; unpublished B.Sc. thesis, *The University of British Columbia,* Vancouver, 50 pages.

Dumont, R., Coyle, M. and Potvin, J. (2001a): Aeromagnetic total field map British Columbia: Nakina Lake, NTS 104N/1; *Geological Survey of Canada,* Open File 4091.

Dumont, R., Coyle, M. and Potvin, J. (2001b): Aeromagnetic total field map British Columbia: Nakina, NTS 104N/2; *Geological Survey of Canada*, Open File 4092.

Dumont, R., Coyle, M. and Potvin, J. (2001c): Aeromagnetic total field map British Columbia: Sloko River, NTS 104N/3; *Geological Survey of Canada,* Open File 4093.

English, J.M., Mihalynuk, M.G., Johnston, S.T. and Devine, F.A.M. (2002): Atlin TGI, Part III: Geology and Petrochemistry of Mafic Rocks within the Northern Cache Creek Terrane and Tectonic Implications; *in* Geological Fieldwork 2001; *BC Ministry of Energy and Mines*, Paper 2002-1, pages 19-29.

English, J.M., Mihalynuk, M.G. and Johnston, S.T., Orchard, M.J., Fowler, M. and Leonard, L. (2003): Atlin TGI, Part II: Lower to Middle Jurassic sedimentation, deformation and a preliminary assessment of hydrocarbon potential of the central Whitehorse Trough and northern Cache Creek terrane; in Geological Fieldwork 2002; *BC Ministry of Energy and Mines*, Paper 2003-1, this volume.

Jackaman, W. (2000): British Columbia Regional Geochemical Survey, NTS 104N - Atlin; *BC Ministry of Energy and Mines*, BC RGS 51.

Levson, V.M. and Blyth, H. (2001): Formation and preservation of a Tertiary to Pleistocene fluvial gold placer in northwest British Columbia; *Quaternary International*; Volume 82, pages 33-50.

Levson, V.M. and Kerr, D.E. (1992): Surficial geology and placer fold settings of the Atlin - Surprise Lake area, NTS 104N/11, 12; *BC Ministry of Energy and Mines*, Open File 1992-7, Scale 1:50 000.

Levson, V.M., Mate, D. and Ferbey, T. (2002): Platinum-group-element (PGE) placer deposits in British Columbia: characterization and implications for PGE potential; in Geological Fieldwork 2001; *BC Ministry of Energy and Mines*, Paper 2002-1, pages 303-312.

Levson, V. M., Kerr, D.E., Lowe, C. and Blyth, H. (2003): Quaternary geology of the Atlin area, British Columbia; *BC Ministry of Energy and Mines*, Geoscience Map 2003-1, Scale 1: 50 000.

Lowe, C. and Anderson, R.G. (2002): Preliminary Interpretations of new aeromagnetic data for the Atlin mpa area, British Columbia; in Current Research; *Geological Survey of Canada*, Paper 2002-A17, pages .

Lowe, C. and Mihalynuk, M.G. (2002): The Atlin Integrated Geoscience Project, northwestern British Columbia - an overview; in Current Research, Part A; *Geological Survey of Canada*, Paper 2002-A17, pages .

Lowe, C., Dumont, R., Coyle, M. and Potvin, J. (2002): Interpretation of new aeromagnetic data, Atlin map area (NTS 104N); Cordilleran Exploration Roundup 2002, Vancouver, British Columbia.

Lowe, C., Mihalynuk, M.G., Anderson, R.G. , Canil, D., Cordey, F., English, J.M., Harder, M., Johnson, S.T., Orchard, M., Russell, K., Sano, H. and Villeneuve, M. (2003): Atlin TGI Project overview, northwestern British Columbia, year three; *in* Current Research, *Geological Survey of Canada*, Paper 2003-A11, 10 p.

Merran, Y. (2002): Mise en place et environnement de depot d'une plate-forme carbonatee intraoceanique: exemple du complexe d'Atlin, Canada; Université Claude Bernard, Lyon, France, unpublished M.Sc. Thesis.

Mihalynuk, M.G. (1999): Geology and Mineral Resources of the Tagish Lake Area; *BC Ministry of Energy and Mines*, Bulletin 105, 117 pages.

Mihalynuk, M.G., Bellefontaine, K.A., Brown, D.A., Logan, J.M., Nelson, J.L., Legun, A.S. and Diakow, L.J. (1996): Geological compilation, northwest British Columbia (NTS 94E, L, M; 104F, G, H, I, J, K, L, M, N, O, P; 114J, O, P); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1996-11.

Mihalynuk, M.G. and Lowe, C. (2002a): Atlin TGI, Part I: An Introduction to the Atlin Targeted Geoscience Initiative; in Geological Fieldwork 2001, *BC Ministry of Energy and Mines*, Paper 2002-1, pages 1-4.

Mihalynuk, M.G., Johnston, S.T., Lowe, C., Cordey, F., Devine, F.A.M., English, J.M., Merran, Y. and Larson, K. (2002b): Atlin TGI Part II: Regional mapping highlights from the Nakina area (104N/1, 2) northwestern BC; *in* Geological Fieldwork 2001; *BC Ministry of Energy and Mines*, Paper 2002-1, pages 5-18.

Mihalynuk, M.G., Johnston, S.T., English, J.M., Cordey, F. Bath, A., Blackwell, J. Villeneuve, M., Roenitz, O., Leonard, L., Devine, F.A.M. and Canil, D. (2003a): TGI Part II: Regional geology and mineralization of the Nakina area, (NTS 104N/2W and 3); *in* Geological Fieldwork, *BC Ministry of Energy and Mines*, Paper 2003-1, this volume.

Mihalynuk, M.G., Cordey, F., Villeneuve, M. and Devine, F.A.M. (2003b): TGI Part III: Geological setting of Massive Sulphide mineralization at the Joss'alun occurrence; *in* Geological Fieldwork, *BC Ministry of Energy and Mines*, Paper 2003-1, this volume.

Monger, J.W.H. (1975): Upper Paleozoic rocks of the Atlin Terrane, northwest British Columbia and south-central Yukon, *Geological Survey of Canada*, Paper 74-47, 63 pages.

Nassichuk, W.W. (1975): Upper Permian ammonoids from the Cache Creek Group in western Canada; *Journal of Paleontology*, Volume 51, pages 557-590.

Orchard, M.J., Cordey, F., Rui, L., Bamber, E.W., Mamet, B., Struik, L.C., Sano, H. and Taylor, H.J. (2001): Biostratigraphic and biogeographic constraints on the Carboniferous to Jurassic Cache Creek Terrane in central British Columbia; *Canadian Journal of Earth Sciences*, Volume 38, pages 551-578.