

EXPLORATION AND MINING IN Omineca Region, British Columbia

By Paul Wojdak, MSc, PGeo
Regional Geologist, Smithers

SUMMARY AND TRENDS

Exploration spending is estimated to be \$37 million and expenditure on mine development at Mount Milligan was about \$33 million. There was about 83 000 m of exploration drilling spread between 18 projects. Although there is limited data for 2009 it is apparent that activity level increased in 2010. It is difficult to make a comparison with levels of activity in prior years because the area of the region has been changed to reflect Government's current administration boundaries, such that the Barkerville to Williams Lake area was transferred to Thompson-Okanagan-Cariboo region. Readers are referred to the Thompson-Okanagan-Cariboo chapter for the Gibraltar and Mount Polley mines and Cariboo district exploration projects. Figure 1 and Table 1 portrays mines and exploration activity in the new Omineca region.

Thompson Creek Metals Company Inc acquired the Mount Milligan copper-gold project in 2010 by acquisition of Terrane Metals Corp and is proceeding with mine development. Initial activities at Mount Milligan comprise construction of the access road and power line, installation of the construction camp and land clearing. Estimated cost for the entire project is \$915 million. Kemess South gold-copper mine is scheduled to close in the first quarter of 2011. Northgate Minerals Corp reactivated work on the Kemess North deposit to evaluate potential for a block-cave underground mine. More closely-spaced drilling in a part of the deposit identified higher gold and copper grades, including values of more than 2 g/t Au over significant intersections. Exploration activity in Omineca region focused on gold exploration in the Nechako Plateau south of Vanderhoof and copper-gold in Quesnel terrane northward of Prince George. Significant efforts were also devoted to rare metals and to lead-zinc in the Rocky Mountains, and to a new style of nickel deposit northwest of Fort St. James.

In the Nechako area, drilling by Richfield Ventures Corp on its Blackwater-Davidson epithermal gold prospect continued throughout the year, producing a number of wide, bulk-tonnage grade, gold intercepts (*e.g.* 1.25 g/t Au over 361 m). A resource estimate is anticipated in mid-2011. This new prospect is located close to, and in similar geological setting to the long-known Capoose silver-gold prospect. There, drilling by Silverquest Resources Ltd also resulted in significant intercepts. Junior explorers rushed to stake ground in the rapidly emerging Nechako gold district that extends 140 km south to the Newton prospect of Amarc Resources Ltd

and 165 km west to the Coles Creek property of Callinan Mines Ltd (see Skeena Region).

In the northern Quesnel porphyry belt, there were major drilling programs at Kwanika (by Serengeti Resources Inc) and Mount Milligan in addition to that at Kemess North. Exploration at Mount Milligan is on deep targets, including below the designed open pit. The latter holes must be done in the time prior to pit development. Two major companies, Xstrata Copper Canada Ltd and Teck Resources, conducted grassroots programs in search of porphyry copper-gold deposits in the extensively overburden-covered area between Prince George and Mount Milligan.

First Point Minerals Corp and Cliffs Natural Resources Inc explored Cache Creek terrane ultramafic rocks northwest of Fort St. James for a new type of nickel deposit. Under select geologic conditions nickel in serpentinite is present as a native nickel-iron alloy that may be amenable to low-cost gravity and magnetic separation rather than needing the more expensive conventional flotation and smelting.

In the northern Rocky Mountains, many junior companies acquired ground in a belt of carbonatite and affiliated alkaline intrusions that are prospective for rare metals. Taseko Mines Limited conducted a major investigation of the Aley niobium prospect. Closer to Prince George, Canadian International Minerals explored the Wicheeda carbonatite complex for lanthanum, cerium and other light rare earth elements. In the Kechika district, Canada Zinc Metals Corporation reactivated drilling for bedded lead-zinc mineralization on the Akie property.

METAL MINES

The **Kemess South** copper-gold mine is located 430 km northwest of Prince George or 240 km north of Smithers and is 100% owned by Northgate Minerals Corporation. The mine operated at 52 000 tonnes per day and employed 350 people full time. Production in 2010 is forecast at 3170 kg Au (102 000 ounces) and 20 400 tonnes Cu. Proven reserves at the beginning of 2010 stood at 22.66 Mt grading 0.28 g/t Au and 0.14% Cu. In 2009, Kemess processed 18 353 000 tonnes of ore producing 5382 kg Au (173 040 ounces) and 23 812 tonnes of Cu. Metal recoveries were 66% for gold and 81% for copper. The net cash cost of production was \$348 per ounce of gold. Cut-off grade (in August 2010) was 0.09% Cu and 0.19 g/t Au. Mining of Kemess South is scheduled to end

Mines and Major Exploration Projects Omineca Region

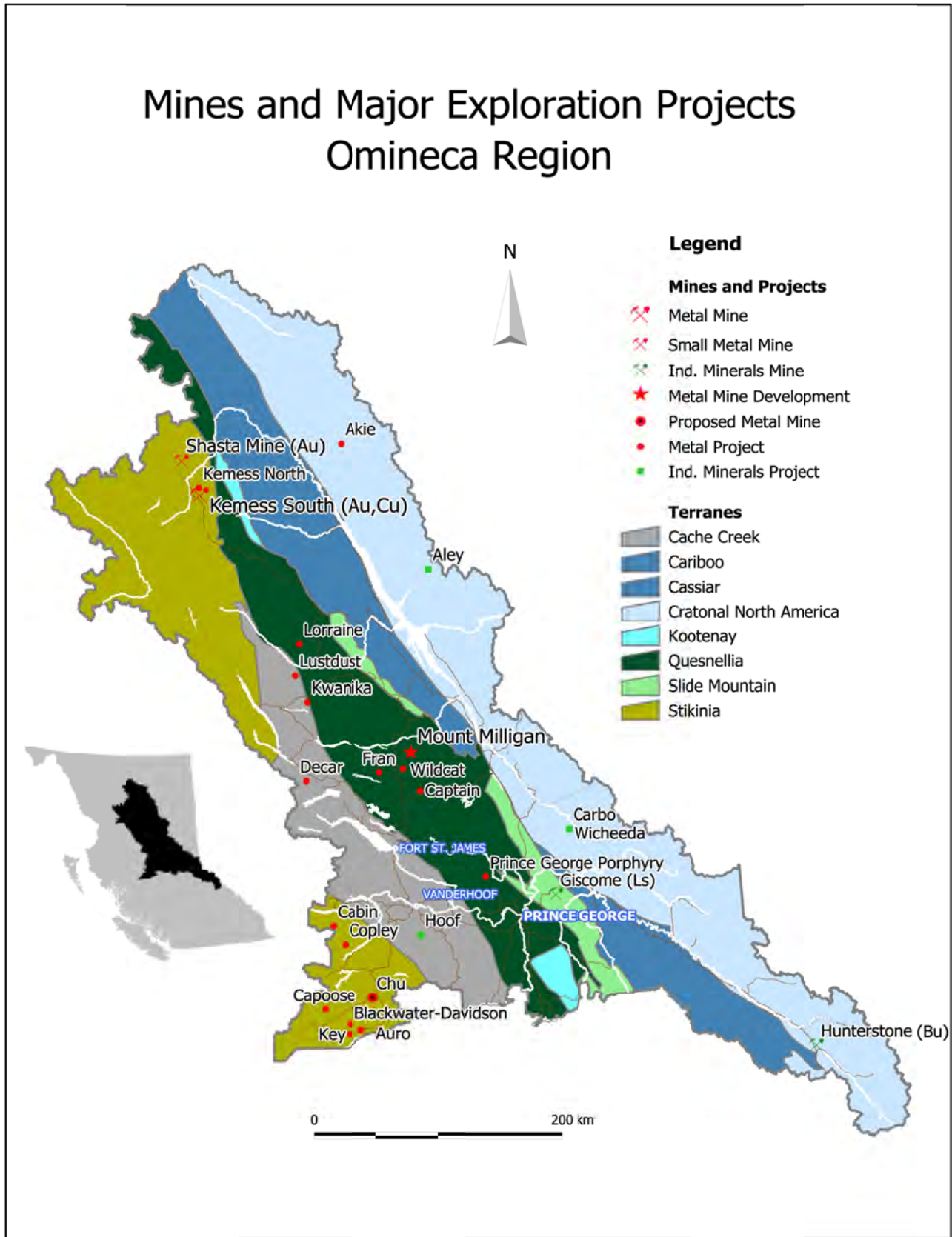


Figure 1. Mines and Exploration Projects in Omineca Region.

TABLE 1. MAJOR EXPLORATION PROJECTS, OMINECA REGION

Property	Operator	MINFILE (1:20 000 Map Sheet)	Commodity	Deposit Type	Work Program
Akie	Canada Zinc Metals Corp	094F 031	Zn, Pb, Ag	Massive Sulphide	DD (6228 m, 13 holes); A
Aley	Taseko Mines Limited	094B 027	Nb, REE	Carbonatite	G; DD (4516 m, 23 holes)
Auro	Gold Reach Resources Ltd	(093F.017)	Au	Epithermal vein	AB (1598 km); G; 3D-IP (80 km); GC (3000 soil)
Blackwater Davidson	Richfield Ventures Corp	093F 037	Au	Vein	DD (~20 000 m); A (20 km); IP
Cabin	Paget Minerals Corp	093F 038	Au, Ag	Epithermal	IP, MG; DD (1418 m, 10 holes)
Capoose	Silver Quest Resources Ltd	093F 040	Ag, Au	Vein	MG (115 km); IP (10 km); DD (10 590 m, 37 holes)
Captain	Orestone Mining Corp	093J 026	Cu, Au	Porphyry	GC (soil); IP (2 km); DD ?
Carbo	Canadian International Minerals Inc	093J 014	REE	Industrial Mineral	AB-MG-RD; G; GC; DD (1939 m, 9 holes)
Chu	TTM Resources Inc	093F 001	Mo	Porphyry	GC (4430 samples); MS; DD (1162 m, 6 holes)
Copley	Kootenay Gold Corp	(093F.076)	Au	Epithermal	GC; DD (1000 m, 11 holes)
Decar	Cliffs Natural Resources Inc	093K 041	Ni	Disseminated	G; MG; IP; DD (2430 m, 10 holes)
Fran	Yankee Hat Minerals Ltd	093K 108	Au, Cu	Vein	DD (up to 10 000 m ?)
Hoof	Porpoise Bay Minerals Ltd	093G 018	Mg, Ni	Industrial Mineral	A (2.7 km)
Kemess North	Northgate Minerals Corp	094E 094	Cu, Au	Porphyry	DD (16 439 m)
Key	Troymet Exploration Corp	093F 069	Au	Epithermal	G; P; IP; GC (soil);
Kwanika	Serengeti Resources Inc	093N 073	Cu, Au	Porphyry	DD (7 600 m, 31 holes)
Lorraine	Teck Resources Limited	093N 002	Cu, Au	Porphyry	G; GC (soil)
Lustdust	Alpha Gold Corp	093N 009, 044	Au, Cu	Skarn	DD (? m)
Mt Miligan	Thompson Creek Metals Company Inc	093N 194	Au, Cu	Porphyry	DD (~8000 m); IP (Titan-24, 50 km)
Nonda	Stikine Energy Corp	(094N.083)	Industrial Mineral	Industrial Mineral	BU (450 t); Pilot Plant; P, G
Prince George Porphyry	Xstrata Copper Canada Ltd	(093J.015, 025)	Cu, Au	Porphyry	GC; G; DD (~1500 m ?)
Shasta Mine	Sable Resources Ltd	094E 050	Au	Vein	mining activity
Wicheeda	Spectrum Mining Corp	093J 014	Ce, La, Nd	Carbonatite	MS (400 kg); GC (soil)
Wildcat	Cayden Resources Inc	093N 228	Cu, Au	Porphyry	AB-EM-MG (310 km)

Work Program Abbreviations:

A = access (trail, road construction on claims); AB-EM = airborne electromagnetics; AB-MG = airborne magnetics; AB-RD = airborne radiometrics; BU (X tonnes) = bulk sample (weight in tonnes if known); CD = condemnation drilling; CQ = coal quality testing; CT = carbonization test (coal); DD (Xm) = diamond drilling totalling X metres; EN = environmental baseline studies/monitoring, remediation work; FS = feasibility studies; G = geology, mapping etc.; GC = geochemical sampling (rock, soil, silt etc.); GD = geotech drilling; GP = geophysics (general); IP = Induced Polarization; 3D-IP; MG = magnetics; MK = marketing (primarily for industrial mineral products); MS = metallurgical studies; OB = overburden drilling; OP-BU = open-pit bulk sample; P = prospecting; PD = percussion drilling; PF = pre-feasibility studies; R = reclamation; RC = reverse circulation drilling; TR = trenching; UG (Xm) = X metres of underground development; UG-BU = underground bulk sample; UT = UTEM; VLF; WT = washability test (coal)

in January 2011. Milling of stockpile ore will continue through February with closure to follow in March.

Kemess South was a very successful mine after overcoming construction shortcomings, low metal prices and a change of ownership in its early years. Kemess South produced 91 248 kg (2 933 638 oz) of gold and 349 043 tonnes of copper between October 1998 and September 2010, from 208 218 000 tonnes of ore.

Kemess South (MINFILE 094E 094) is a gold-rich porphyry copper deposit developed in a potassium-rich calcalkaline monzodiorite. The 200 Ma pluton is flat-lying, underlain and partially overlain by Takla Group augite basalt to andesite; overlying all this are epiclastic rocks of the Lower Jurassic Toodoggone Formation. Mineralization is a vein stockwork of quartz, magnetite and chalcopyrite with attendant biotite and sericite alteration; copper grade is directly proportional to quartz vein content. Mineralization is best developed in the pluton and weakly developed in Takla volcanic rocks. A leached and then supergene enriched zone is developed below the epiclastic rocks that comprises up to 70 m of

sparse native copper and lesser cuprite, covellite and chalcocite (G. Skrecky, personal communication, 2010). Gold grade is similar to hypogene ore in both the leached cap and supergene zones. The deposit is elongated east-west, segmented into West and East sub-pits by a central “high” of Takla Group rocks. To the north, the deposit is truncated by a normal fault with the north side displaced upward.

Mining of the West Pit was terminated approximately in August 2009 by failure of the Toodoggone epiclastic rocks at the west end of the pit. The epiclastic rocks are high in montmorillonite and decompose quickly to material having an angle of repose of only 8° (A. Stewart, personal communication, 2010). Since then waste rock and tailings were placed in the west pit, impounded by the central “high” (Figure 2). In the East pit, the North wall is also problematic. Graphitic sedimentary rocks of the Asitka Group dip south into the pit and, where undercut by mining, are prone to failure (refer to Figure 2).

The **Kemess North** deposit (MINFILE 094E 021) lies 5.5 km from Kemess South mine. It is developed in a



Figure 2. Kemess South mine showing failures on the north wall that result from graphite-bearing Asitka Group sedimentary rocks. A basement “high” of Takla rocks separates tailings in the West Pit from active mining in the East Pit.

separate monzodiorite pluton, also sill shaped, about 700 by 500 m in size and dated at 202 Ma. The intrusive body does not outcrop but its presence is revealed by an intense gossan developed in the overlying Takla Group volcanic rocks (Figure 3). Work in 2005 delineated a resource of 720 Mt grading 0.15% Cu and 0.30 g/t Au but an open pit mine plan was not approved by Federal and Provincial regulators. Higher metal prices in 2009 prompted Northgate to reconsider the project in 2010 as an



Figure 3. Kemess North, gossan developed in Takla Group andesite.

underground development. The core of Kemess North was estimated to comprise 70 Mt containing 0.65 g/t Au and 0.3-0.4% Cu. This area was targeted in a 16 000 m drill program (Figure 4) to define this resource block better and to assess its geotechnical characteristics for possible block-cave mining.

Results of the 2010 program show the northeast quadrant of Kemess North is higher grade than predicted from the widely spaced 2005 drillholes. Hole KN-10-03 returned a 60 m intercept grading 0.95% Cu and 3.37 g/t Au, the highest grade from the entire Kemess property. The company reports the 2005 block model tended to homogenize gold and copper grades. Application of geologic criteria, such as alteration, enables definition of grade domains containing from 1 g/t Au to more than 2 g/t Au. A resource calculation is in progress. Mineralization in Kemess North is a quartz-magnetite-pyrite-chalcopyrite stockwork associated with early K-feldspar and biotite alteration. Grade tenor is best in the upper portion of the intrusive body, passing into a quartz-pyrite stockwork with chlorite alteration at depth. The northeast extent of the deposit is cut off by the Kemess North fault with apparent reverse displacement of at least 1000 m (C. Edmunds, personal communication, 2010).

The **Shasta** gold mine (MINFILE 094E 050) is located 30 km north of Kemess and owned by Sable Resources Ltd. Ore is trucked 11 km to a gravity mill at the former Baker mine. Upgrade work continued throughout the year toward maintaining a mining and milling rate of 180 tonnes per day, but production was only reported for two months (September and October) totalling 1450 gold-equivalent ounces. This was sufficient to purchase a 3.5 yard scoop tram and single-boom jumbo drill. No other production data was available and there is no statement of ore reserves or mineral resources. Shasta is an epithermal quartz-calcite vein and breccia system cutting Takla Group volcanic rocks. Native gold and silver, electrum and acanthite occur, along with base metal sulphide minerals.



Figure 4. Kemess North, geologists and drill crew discuss drilling progress.

MINE DEVELOPMENT PROJECTS

Thompson Creek Metals Company Inc acquired the **Mount Milligan** copper-gold project in 2010 by purchasing Terrane Metals Corporation in a cash and share deal worth approximately \$650 million. By the deal, Goldcorp Inc, which was majority owner of Terrane, acquired an 8% interest in Thompson Creek and \$240 million in cash. Mount Milligan is fully approved and permitted to build a 60 000 tonne per day open pit mine estimated to cost \$915 million. Proven and probable ore reserves are stated at 482 Mt grading 0.20% Cu and 0.39 g/t Au.

Construction is expected to take 2.5 years. Development work in 2010 comprised access road construction, site clearing, start on a 90 km power line and installation of a 250-man camp (to be expanded later to house 600). The site is relatively flat and without major impediments to development (Figure 5). Thompson Creek estimates capital expenditure at Mount Milligan in 2010 at \$33 million.

Mount Milligan (MINFILE 093N 194) is an alkalic porphyry copper-gold deposit in Quesnel terrane with a measured and indicated resource of 706.7 Mt grading 0.18% Cu and 0.33 g/t Au. Mineralization is associated with the Southern Star, MBx and barren Goldmark monzonite stocks dated at 183 to 186 Ma. This makes the mineralizing event 20 Ma younger than most other Quesnel terrane porphyry deposits. The stocks are satellites of an intrusive complex consisting of gabbro, monzonite and hornblende granite. Nicola Group volcanic stratigraphy at Mount Milligan dips about 45° east and the mineralized stocks plunge 45° west. Copper and gold are not coincident; copper occurs mainly within intrusive rocks, the MBx stock in particular, whereas gold occurs in adjacent basalt, mainly in fracture veins. The principal fracture-filling mineral is pyrite with lesser quartz and minor chalcopyrite. Alteration comprises widespread pervasive biotite, albite and local magnetite, as in the MBx (magnetite breccia) zone. In addition, epidote is prominent in the 66 zone though it is also common throughout the district.

Ore definition drilling at Mount Milligan (from 1990 era) was conducted primarily to a 300 m pit depth. A few deep holes show the ore zone continues beyond the planned pit depth. Recent exploration includes high-resolution airborne magnetics (in 2008) and a 50 km Titan-24 IP survey (in 2010). These surveys reveal several targets for deep mineralization (D. O'Brien, personal communication, 2010) including Camp Hill (Figure 6) where early exploration holes intersected favourable geology but low copper and gold grades near surface. All these targets are being tested in a 11 000 m drill program that began in September 2010 and is expected to conclude in early 2011.



Figure 5. Mount Milligan, Darrin O'Brien (Thompson Creek Mining) and Jay Fredericks (British Columbia Geological Survey) view site of planned open-pit development.



Figure 6. Mount Milligan, geologic discussion at the exploration camp; Camp Hill in the background overlies one of several deep exploration drill targets.

MINE EVALUATION PROJECTS

The **Chu** molybdenum project (MINFILE 093F 001), located 80 km south of Vanderhoof and owned by TTM Resources Inc, is in the pre-application stage of the BC environmental assessment process. The company contemplates an open pit mine operating at 60 000 tonnes per day. Measured plus indicated resources at Chu are

estimated at 370.64 Mt grading 0.059% Mo and 0.035% Cu at a cut-off grade of 0.04% Mo.

A quartz-molybdenite stockwork is developed in a composite stock and adjacent siltstone and lesser andesite of the Hazelton Group (Figure 7). The principal hostrock is biotite hornfels derived from the sedimentary rocks. The stock comprises hornblende granodiorite and a peripheral phase of leucocratic quartz-feldspar porphyry, which is the next most prominent hostrock for molybdenum. TTM dated molybdenite in the pluton at 53.6 Ma by the Re-Os method (W. Raven, personal communication, 2010). It appears that early coarse pyrite-chalcocopyrite-quartz veins, with chlorite alteration, are cut by younger quartz veins with a molybdenite selvage. Spessartine garnet is prominent locally as an ore-related alteration mineral (Figure 8). A north-northeast shear zone with inferred low molybdenum grade bisects the ore zone; however, core recovery from holes in the shear zone is reduced and molybdenite loss may account for the lower grade.

Extensive soil sampling surveys (224 line km) were conducted on the Chu property in 2010, including



Figure 7. Chu, Wes Raven (TTM Resources) reviews molybdenum assay data and drill core.



Figure 8. Chu, hydrothermal spessartine garnet in drill core; also visible are fractured siltstone hornfels and granodiorite.

recently acquired claims. Molybdenum determinations were done in the field using a portable XRF analyzer, with check-work performed at a conventional laboratory - a lower cost and quick turnaround method becoming widespread in the exploration industry. A follow-up core drilling program (2000-3000 m) began in mid-November.

EXPLORATION

Porphyry Copper Projects in Quesnel Terrane

Most porphyry copper exploration in the Omineca region took place in Quesnel terrane, an upper Triassic volcanic island arc containing coeval plutons, which is prolific in porphyry copper-(gold-molybdenum) deposits throughout its 1000 km length in British Columbia. Omineca region encompasses the northern 300 km of this belt and includes Mount Milligan (described above). Kemess (also described above) lies in Stikine terrane, another volcanic island arc that contains pre-accretion porphyry copper-(gold-molybdenum) deposits. The Stikine terrane is restricted in extent in Omineca region. The projects described below are in a north to south progression.

Gold Fields Toodoggone Exploration Corp conducted a limited geochemical survey at the **Mex** prospect (MINFILE 094E 057), 3 km southeast of the Pine porphyry copper-gold prospect. Mex comprises an advanced argillic alteration assemblage with a strong gold-copper geochemical anomaly (R. Sherlock, personal communication, 2010). Mex is located 20 km north of Kemess mine.

Serengeti Resources Inc drilled on the **Kwanika** copper-gold property (MINFILE 093N 073) 140 km northwest of Fort St. James, to augment mineral resources in the South zone. Two drill rigs completed 7600 m in 31 holes (Figure 9). The company announced the program



Figure 9. Kwanika, Hugh Samson (Serengeti Resources) at a reclaimed and clover-seeded drill site. Geochemistry of the organic layer in the surrounding pine forest is a successful new exploration technique.

“will likely result in an expansion of the mineralized envelope, albeit at a generally lower grade” than previous holes. From past work, the inferred resource in the South zone is 129.1 Mt grading 0.30% Cu, 0.09 g/t Au, 0.01% Mo and 1.76 g/t Ag at a cut-off grade of 0.25% Cu equivalent. The Central zone has an indicated resource of 182.6 Mt grading 0.29% Cu and 0.28 g/t Au at a cut-off grade of 0.25% Cu equivalent. In a significant advance toward a social license for the project, Serengeti Resources and the Takla Lake First Nation signed an exploration access agreement in August.

The Kwanika deposit is within medium grained to porphyritic monzonite of the multiphase Hogem batholith. Mineralization is dated at 198.6 Ma (H. Samson, personal communication, 2010). The Central and South zones are both characterized by strong K-feldspar alteration but a strong quartz stockwork present in the Central zone (Figure 10) is not well developed in the South zone. Chalcopyrite and bornite occur in the Central zone but chalcopyrite and molybdenite are the principal ore minerals in the South zone where the gold content is lower. In the Central zone a strong overprint of albite-Fe-carbonate-hematite alteration is developed near the paleo-surface beneath a post-mineral sedimentary basin. A zone of supergene enrichment is present below this paleo-surface, consisting of native copper, chalcocite and covellite (H. Samson, personal communication, 2010).

Teck Resources is earning majority ownership of the **Lorraine** copper-gold prospect (MINFILE 093N 002) under an agreement with Lorraine Copper Corp. Teck conducted an A_H horizon soil geochemical survey, a new technique used successfully at Kwanika to detect mineralization below thick overburden. In addition, core was relogged to apply new ideas on alteration vectors. The aim of the work is to generate new exploration targets. Lorraine is 130 km northwest of Fort St. James.

Oceanside Capital Corp conducted a late-season program on the **Indata** property (MINFILE 093N 192) located 130 km northwest of Fort St James.



Figure 10. Kwanika Central zone, supergene chalcocite in quartz stockwork with overprint of albite-Fe-carbonate-hematite alteration, from drillhole 62.

Mineralization at Indata comprises gold-quartz veins and associated listwanite alteration in rocks of Cache Creek terrane west of the Pinchi fault and, to the east, copper-gold porphyry type in Quesnel terrane volcanic and plutonic rocks. Soil geochemical and IP surveys focused on new targets north and south of previously explored areas.

The **Chuchi North** property of Silver Quest Resources Ltd covers an historic 3.5 km gold-in-soil anomaly near the southerly tail of the Hogem batholith. The claims are located 50 km northwest of Mount Milligan. Geological and soil geochemical surveys were performed. Results will determine if drilling will follow in 2011.

On its **Mount Milligan North** property, Terracast Geological Services carried out preliminary geological work and prospecting, and may drill in 2011.

On the **Wildcat** property (MINFILE 093N 228) 12 km southwest of Mount Milligan, Cayden Resources Inc completed a 310 line km ZTEM and magnetic airborne geophysical survey. This is a new technique capable of mapping resistivity and conductivity anomalies related to porphyry deposits beneath thick overburden. Twelve core holes totalling 2200 m are planned in early 2011.

A 5000 m drill program began in mid-November on the **Fran** prospect (MINFILE 093K 108) located 25 km southwest of Mount Milligan. There is a porphyry-type geological setting at Fran, with small stocks and dikes of diorite to monzonite emplaced into Takla Group volcanic and sedimentary rocks. Gold mineralization comprises fracture controlled quartz-sulphide veins and replacement of wallrock. Previous exploration comprises extensive surface work and 71 core holes. As an example, FR-055 intersected 8.51 g/t Au, 14.8 g/t Ag and 0.25% Cu over 9.55 m. New targets were generated from a computer modelling exercise.

The **Captain** property (MINFILE 093J 026) was also explored late in the season by Orestone Mining Corp. Located 30 km south of Mount Milligan, prospective Quesnel terrane rocks are largely covered by glacial deposits and by Tertiary basalt. The bottom 3.1 m of a 137 m core hole drilled in 2009 returned an assay of 0.16% Cu and 0.34 g/t Au, an encouraging intercept that warrants follow-up. An orientation A_H soil geochemical survey was completed in 2010, to be followed by IP and winter 2010-11 drilling (G. Richards, personal communication, 2010).

The **Prince George** porphyry project of Xstrata Copper Canada Ltd comprises twelve claim blocks in Quesnel terrane between Prince George and Fort St. James. Xstrata has completed grassroots exploration for new porphyry copper deposits in an area of extensive overburden using geochemical and geophysical methods. There are 20 targets; most were identified from the QUEST airborne geophysical survey. MMI geochemistry and limited IP surveying were completed in 2008 and 2009. The program budget was increased in 2010 to

include leaf-litter geochemistry (A_H horizon) and core drilling using an innovative tractor-mounted rig (Figure 11). The rationale for using this piece of equipment is its low mobilization cost and low surface disturbance which facilitates regulatory approval. Many targets were tested, with up to 30 m of overburden, and some holes located new plutons that warrant further drilling in 2011 (M. Keogh, personal communication, 2010). However, the rig was unable to reach bedrock on other targets and a larger drill was brought in to test these. All core logging was done in Prince George (Figure 12).



Figure 11. Kubota-mounted diamond drill used in the Prince George Porphyry project.



Figure 12. Max Keogh (Xstrata Copper Canada) displays drill core from the Prince George Porphyry project.

Nickel, Magnesium and Gold Projects in Cache Creek Terrane

Ultramafic rocks are an integral component of the oceanic Cache Creek terrane (refer to Figure 1). The area of Mount Sydney Williams and Trembleur Lake northwest of Fort St. James is underlain by large bodies of ultramafic rock, extensively converted to serpentinite. Ultramafic rocks have higher nickel contents than other rock types. Normally the nickel is bound up in silicate minerals; mainly olivine in primary ultramafites or in serpentinite in metamorphosed bodies. The high cost of liberating nickel from these silicate minerals precludes them as an economic source of nickel.

First Point Minerals Corporation and their partner, Cliffs Natural Resources Inc, are advancing a new concept in nickel exploration on the **Decar** property near Mount Sydney Williams, 80 km northwest of Fort St. James. The target is awaruite, a naturally occurring iron-nickel alloy documented at several localities around the world. The apparent rarity of the mineral may be a function of its generally fine grain size which renders it difficult to distinguish from more common metallic minerals, such as pyrrhotite and pentlandite (Figure 13). Awaruite is hypothesized to form if olivine is converted to serpentinite under the unusual conditions of low oxygen and low sulphur fugacity. Total nickel content is not enriched over that of the ultramafic parent rock and is typically in the order of 0.2% Ni. The economic



Figure 13. Peter Bradshaw and Trevor Rabb (First Point Minerals) look for awaruite in serpentinite at Decar.

significance of awaruite is that it is dense and highly magnetic, properties that make it amenable to simple methods of concentration that are lower in cost than flotation and smelting required of nickel sulphide ores. First Point conducted a wide ranging reconnaissance program over the past several years before focusing exploration at Decar in 2009 (Figure 14).

Initial field work at Decar mapped the grain size of awaruite across the property. Core drilling focused on areas with the largest grain size, the Baptiste and Sidney target areas which are three kilometres apart. The drilling program totalled 2430 m in 10 holes. Serpentinized peridotite contains relict pyroxene and accessory magnetite, chromite and sub-millimetre size disseminated awaruite (Figure 15). Analytic work distinguished nickel alloy from total nickel. In the principal Baptiste zone, nickel alloy grades from 0.105% to 0.145% Ni from the top of bedrock to the end of all seven holes, ranging up to 341 m deep. Total nickel content is 0.22-0.24% Ni. First Point reported that several tonnes of drill core will be used in mechanical mineral processing test work.

Kilometre 26 is a gold (and nickel) project conducted by Oroandes Resource Corporation under an



Figure 14. Aligning the drill for a new hole at Decar.



Figure 15. Darcy Vis and Ian Carr prepare geotechnical and geological core logs at Decar.

agreement with Eastfield Resources Ltd. The property is 55 km northwest of Fort St. James and underlain by serpentinite along the Pinchi fault. In the 1980s an auriferous boulder exhibiting listwanite alteration was discovered but its source was not found. In late 2010, soil geochemical, magnetic and IP surveys were conducted. In addition, analytic work was undertaken to determine if nickel is present in alloy form (see Decar above).

At the **Hoof** property on Sinkut Mountain, 20 km south of Vanderhoof, magnesium is of primary interest (Figure 16). If economic, nickel might be recovered as a byproduct. Work by Porpoise Bay Minerals Limited in 2008, including 10 core holes totalling 1000 m, determined the Sinkut ultramafic body contains 20-26% Mg (Figure 17). A preliminary engineering study indicates the deposit should be considered for mining to produce magnesium ore. A 2500 m drilling program is set to begin in mid-winter of early 2011.

Alpha Gold Corporation conducted a drilling program on its **Lustdust** gold project (MINFILE 093N 009, 044), located 250 km northwest of Prince George. Gold and copper occur in skarn and manto zones developed within a sequence of limestone, siltstone and



Figure 16. Rupert Seel on the Sinkut Mountain ultramafic body, Hoof project.



Figure 17. Hoof project, relict orthopyroxene in serpentinite.

mafic tuff of the Cache Creek Group, intruded by the dikes and sills of the Eocene Glover stock. Prior to the program the company announced a resource estimate in the Canyon Creek zone comprising 910 000 tonnes Indicated at a grade of 1.56% Cu, 1.678 g/t Au and 39.3 g/t Ag, and 1 965 000 tonnes Inferred at a grade of 1.34% Cu, 1.716 g/t Au and 32.1 g/t Ag. The calculation was based on 96 drillholes over a strike length of 500 m.

Gold-Silver Projects on Nechako Plateau

The Nechako Plateau comprises an assemblage of Cretaceous to Tertiary volcanic, plutonic and lesser sedimentary rocks that intrude and overlap Stikine and Cache Creek terranes over a broad area. Basin-and-range style block faulting along northeast and northwest trends characterizes the area. Key stratigraphic components include the Cretaceous Bowser Lake and Kasalka groups, the Tertiary Ootsa Lake and Endako groups, and, in the Stikine basement, the Jurassic Hazelton Group.

Numerous gold-bearing intercepts at **Blackwater-Davidson** (MINFILE 093F 037), justified Richfield Ventures Corp upgrading 20 km of access road, installing a year-round camp and expanding its two year drill program to a planned 50 000 m. The property is located 100 km due south of Fraser Lake (150 km by road from Vanderhoof). The HQ drilling was on a 50 m grid (Figure 18) and will enable resource estimation in 2011. About 15 500 m of the program is expected to be done in 2010. A deep-penetration IP survey was completed to help interpretation and drilling. The gold zone straddles the boundary between a claim that is 100% owned by Richfield and one that is 75% owned by Richfield and 25% by Silver Quest Resources Ltd. Later in the year, once Richfield had earned its interest in the joint claim, the drilling focused on the wholly-owned tenure until Silver Quest determines how it wants to manage its interest. Representative intercepts from the gold zone include:

- 0.76 g/t Au and 3.1 g/t Ag over 312 m in BW-63 (Figure 19),
- 1.57 g/t Au and 6.7 g/t Ag over 260.3 m in BW-64,
- 1.51 g/t Au and 5.7 g/t Ag over 227 m in BW-68 (Figure 20) and
- 0.59 g/t Au and 5.6 g/t Ag over 67 m in BW-86 (Figure 21)

The principal hostrock is rhyolite breccia consisting of flow-banded fragments that is assigned to the Upper Cretaceous Kasalka Group. Volcanic breccias of uncertain origin are also important (refer to Figure 21) which contain clasts of similar size and shape but different alteration and mineralization. Gold mineralization is unusual in character, but similar to the nearby Capoose deposit. Considerable insight is gained from historical work there (see Capoose below).



Figure 19. Blackwater-Davidson Hole 63, black sulphide 'specks' and 'dendrites' surrounded by silica coronas; part of 312 m interval that grades 0.76 g/t Au.



Figure 20. Blackwater-Davidson Hole 68, black sulphide 'specks' and 'dendrites' with faint breccia texture in rhyolite; part of 227 m interval that grades 1.51 g/t Au.



Figure 18. Diamond drill at Blackwater-Davidson gold project.



Figure 21. Blackwater-Davidson Hole 68, rhyolite breccia with grey silica clasts, brown sphalerite clasts and pale kaolin clasts; kaolin rims on many clasts; part of a 67 m interval that grades 0.59 g/t Au.

Mineralization comprises fine disseminations and minute discontinuous black veinlets (“dendrites”) thought to include sulphide minerals. The sulphides commonly exhibit coronas of very fine silica (refer to Figures 19 and 20). Dark red-brown to black, manganese-rich garnet that characterizes the Capoose deposit (see below) occurs locally as irregular clusters in rhyolite (Figure 22). It also exhibits silica coronas. Elsewhere, disseminated pyrite in rhyolite is replaced by pyrrhotite, sphalerite and fine black sulphide. Features prevalent in volcanic breccia are rhyolite clasts, some with kaolinite rims, wholly kaolinized clasts and sphalerite clasts (refer to Figure 21). Throughout the gold zone, veins are rare and, where present, are medium to coarse grained and appear to be late stage. Pyrite and rare vivianite occur on late fractures.

On the **Capoose** project (MINFILE 093F 040), Silver Quest Resources Ltd completed 37 core holes totalling 10 598 m aimed at upgrading and expanding the gold-silver resource (Figures 23, 24). Capoose lies 25 km northwest of Blackwater-Davidson in the Fawnie Range. It was discovered in 1970, but mainly explored by Granges Ltd from 1976 to 1985. The property was dormant until it was reactivated by Silver Quest in 2008. Based on drilling up to 2010, a new resource estimation calculated the inferred mineral resource at 53.45 Mt in the inferred category grading 0.41 g/t Au and 23.9 g/t Ag at a gold-equivalent cut-off of 0.4 g/t Au. The mineralized zone is approximately 1000 m long and trends north-south. Southward, near its midpoint, the zone branches into west and east limbs, wishbone shaped. Magnetic and induced polarization surveys were conducted to help extend the zone. One of the best holes drilled in 2010, D-10-127 intersected 0.74 g/t Au and 9.37 g/t Ag over 301.5 m. Significant zinc occurs throughout the 301.5 m length, as demonstrated by sub-intervals of 0.74% Zn over 48 m, 0.75% Zn over 26 m and 0.43% Zn over 26 m.

Mineralization at Capoose shares many similarities with Blackwater-Davidson. Capoose was the subject of a

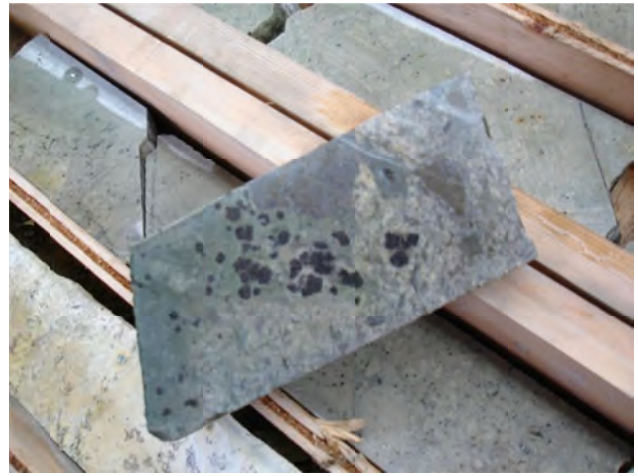


Figure 22. Blackwater-Davidson, cluster of dark garnet and surrounding silica corona, within rhyolite (image out of focus).



Figure 23. Diamond drill at Capoose in the Fawnie Range.



Figure 24. Capoose, core logging, sampling and storage facility within pine beetle-killed forest.

comprehensive and insightful study by Kathryn Andrew (MSc thesis, 1988). The hostrock is subaerial rhyolite, likely ignimbrite although primary textures are poorly preserved. They are variously flow banded, fragmental and spherulitic with rare quartz phenocrysts but containing 1 to 5% spessartine garnet that commonly lines

cavities (D. Pawliuk, personal communication, 2010). The rocks are dated at 71-72 Ma and are correlated with the Kasalka Group. As determined by Andrew, Capoose garnets are among the most manganese-rich garnets reported in the literature. Garnet is dark brown to black (Figure 25) but is pink under a hand lens and surrounded by black material (exsolved manganese oxide) and very fine grained pyrite, sphalerite and galena. Garnets are anhedral and irregularly shaped, as are galena and sphalerite. Andrew reported that silver and gold are associated with the base metals as microscopic inclusions of tetrahedrite and pyrrargyrite.

Garnets exhibit an aphanitic bleached halo, or corona. Andrew investigated the parameters of garnet and sulphide deposition and formation of the quartz-sericitic coronas by microprobe analysis, fluid inclusion study and stable isotope (oxygen and hydrogen) determinations. She determined that garnet formed from a juvenile fluid at magmatic temperatures (*circa* 600°C) and the alteration coronas formed later from invasion of low salinity (meteoric) fluids at temperatures of about 300°C. Base and precious metal sulphides formed at an intermediate stage and may have been nucleated by garnet grains. Veins are rare at Capoose; however, locally coarse grained garnet-sphalerite-galena-pyrite veins occur that are up to 25 cm wide. In one unusual instance a fracture-filling hydrothermal vein comprises equal amounts of 2-4 mm euhedral garnet and pyrite.

The **Auro** claims of Gold Reach Resources are located in between Capoose and Blackwater-Davidson. An airborne geophysical survey (1598 line km) was followed by extensive soil geochemistry (over 3000 samples), three-dimensional IP (80 km) and geological mapping. Late season core drilling was planned.

The **Key** property (MINFILE 093F 069) is owned by Troymet Exploration Corp and adjoins the Blackwater Davidson property to the south. Historic, overlapping soil surveys by three different operators were integrated and found to outline a broad trend of anomalous zinc, copper, lead, arsenic, gold and silver, and to correspond with



Figure 25. Capoose Hole 127, specimens from an interval rich in garnet, note anhedral shape.

anomalous gold values from bedrock. Bedrock in the target area includes garnet-bearing rhyolite with associated pyrrhotite and sphalerite. An induced polarization survey was underway at time of writing.

Geo Minerals Ltd commenced geological mapping, prospecting and soil geochemical surveying in October on its **West Blackwater** claims.

The **Cabin** gold-silver prospect (MINFILE 093F 038) 22 km southwest of Fraser Lake is under exploration by Paget Minerals Corp. The property was acquired by a regional program that was a Joint Venture with Richfield Ventures Corp. It was subsequently assigned to Paget under an option agreement. Mineralization comprises veins, stockwork and breccias over an area of 600 m by 1000 m within a felsic pluton. A total of 72 rock chip and grab samples average 0.96 g/t Au, 73.4 g/t Ag, 0.46% Zn and 0.36% Pb. An induced polarization and drilling program began in mid-October. The property was not visited.

Copley is a new gold property under exploration by Kootenay Gold Corp located 35 km south of Fraser Lake and 10 km southeast of the Holy Cross epithermal prospect (MINFILE 093F 029). Initial work by a team of geologist and prospectors found spherulitic to tuffaceous rhyolite, of uncertain stratigraphic correlation, that is fractured and cut by quartz veins over an area of 55 m by 150 m. Channel samples show the entire area is anomalous in gold and range up to 10.02 g/t across 2 m. In addition to silicification, alteration includes argillic (celadonite) and brick-red hematite (R. Thompson, personal communication, 2010). A drill program began in November and completed 11 holes (1000 m) in December.

Polymetallic Massive Sulphide Projects in Northern Rocky Mountains

Sedimentary exhalative (SEDEX) lead-zinc-silver-barite deposits occur as a major metallogenic district in Selwyn Basin, Yukon and its southern arm in British Columbia, the 500 km long Kechika Trough. Most Selwyn Basin and all Kechika Trough SEDEX deposits are of similar upper Devonian age. In the Kechika Trough the deposits are within the Gunsteel Formation.

Canada Zinc Metals Corp completed an additional eleven core holes totalling 6128 m on its **Akie** SEDEX zinc-lead project. The property is located 260 km north-northwest of Mackenzie and is underlain by folded and faulted shale and siltstone of the regionally mineralized Gunsteel Formation. At Akie, the Cardiac Creek deposit (MINFILE 094F 031) has an inferred resource of 23.6 Mt grading 7.6% Zn, 1.5% Pb and 13 g/t Ag. Three holes were drilled in the central to northwest edge of the Cardiac Creek deposit, four holes tested the Northwest Extension target and four holes explored the North Lead anomaly. The steep topography (Figure 26) results in



Figure 26. North Lead anomaly at Akie, two drill pads (not in use) are visible on the steep mountainside.

longer holes, 500-600 m deep, while the difficult ground requires large drill rigs and sturdy platforms (Figure 27).

Stratigraphy of the mineralized zone comprises (N. Johnson, personal communication, 2010):

- Hangingwall shale with nodular barite and pyrite laminae; 10-30 m thick
- Shale with very fine grained, laminated massive pyrite; 10-25 m thick
- Ore horizon: laminated pyrite, sphalerite and galena; 10-30 m thick
- Barite, massive sand-size grains, not laminated; 1-10 m thick

The hangingwall nodular barite is distinctive (Figure 28) and may be more extensive than the ore horizon. A heterolithic debris flow occurs below the ore sequence; below the centre of the Cardiac Creek deposit, its matrix is replaced by pyrite.

At the time of writing results from four holes remain to be reported. To date, the most intriguing result is from a Northwest Extension hole which intersected nickel sulphide in a unique debris flow deep in the stratigraphic sequence. It includes a sulphide-replaced interval consisting of massive pyrite and crosscutting sphalerite stringers that assayed 0.60% Ni, 2.69% Zn and 4.4 g/t Ag across 1.17 m. The interval is anomalous in gold, lead, copper, molybdenum, antimony, phosphorus, vanadium



Figure 27. Akie, large drill platform to support a drill rig for deep holes.



Figure 28. Akie, delicate laminae and pearl-like beads of barite in the hangingwall shale of the Cardiac Creek SEDEX deposit.

and thallium. It is reminiscent of bedded nickel mineralization at the similar aged Nick prospect in Selwyn Basin, Yukon. Other Northwest Extension holes intersected variable widths of nodular to massive barite and laminated to thickly bedded pyrite comparable to the Cardiac Creek sequence. No work was done on other targets; the GPS barite-laminated pyrite horizon or the Breccia vein-type showing.

The **Sedex** property comprises four claim blocks in the Kechika lead-zinc district. Rio Grande Mining Corp, under an agreement with Megastar Development Corp, carried out an 1199 line km magnetic survey to assist in interpreting stratigraphy and faults on the property.

Rare Metals in (Northern) Rocky Mountain Carbonatite Belt

The Rocky Mountain carbonatite belt comprises eight known individual carbonatite bodies or clusters spaced over a 1500 km length of the Foreland belt from the U.S. border to near the Yukon border. Aley and Wicheeda are two of these bodies. Alkalic plutons comprising nepheline

syenite and ijolite are associated with some carbonatites in the Rocky Mountain belt, but carbonatites are not known at other alkalic complexes. These carbonatite and alkalic complexes contain a wide spectrum of uncommon, nonferrous metals, such as niobium (Nb), zirconium (Zr) and lithium (Li) and rare earth elements (REEs), such as yttrium (Y), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm) and dysprosium (Dy) that are important in high-technology electronics. There has been a surge in exploration for these rare metals in recent years, especially in 2010.

The alignment of carbonatite-alkalic complexes approximates the ancient North American continental margin, delineated by the facies change from carbonate (continental shelf) to shale (continental slope). Furthermore, their Devonian age corresponds to a period of rifting along the North American margin that produced the Selwyn and Kechika basins.

Taseko Mines Ltd carried out a comprehensive investigation of the **Aley** carbonatite (MINFILE 094B 027) that involved structural mapping, mineralogical study and the drilling of 4516 m in 23 holes (Figure 29). Aley, and its contained niobium deposit, were discovered and explored by Cominco in 1985-86. Taseko acquired Aley and drilled it in 2007. No resource estimate has been reported to date.

The Aley carbonatite occurs as two apparently conformable bodies within siltstone of the Cambrian-Ordovician Kechika Formation. Field work by Duncan McLeish determined that the stratigraphic sequence is overturned and complexly deformed (International Workshop, Geology of Rare Metals in November, 2010). Mineral laminations in the carbonatite that appear to conform to bedding in the adjacent siltstone represent a deformation fabric derived from plastic flow during isoclinal folding and shearing that transposed the carbonatite into a sheet (Figure 30). Subsequent crossfolding produced a dome and basin pattern that led to preservation of the carbonatite in two down-warped basins.

The Aley carbonatite comprises three phases; a narrow border phase of calcite carbonatite, a predominant phase of dolomite carbonatite and a small amount of heavy mineral cumulate as layers and clasts. Ryan Kressall investigated the mineralogy (International Workshop, Geology of Rare Metals, November, 2010). Niobate minerals comprise 1-2% of dolomite carbonatite and up to 5% of the cumulate phase. The cumulate phase consists mainly of magnetite and apatite with minor phlogopite and trace amounts of zircon and baddelyite. Principal niobate minerals are pyrochlore, columbite and fersmite.

Wicheeda is a carbonatite-hosted rare earth elements project 80 km northeast of Prince George (MINFILE 093J 014). Significant drill intercepts with values in Ce, La and Nd were reported by privately owned Spectrum Mining Corp in 2008 and 2009, but the Wicheeda project was



Figure 29. Aley carbonatite showing deformation fabric, image courtesy of Duncan McLeish.



Figure 30. Drill move at Aley, image courtesy of Duncan McLeish.

inactive during 2010. The Wicheeda property comprises two claim blocks. A drilling program was contemplated at the time of writing.

The **Carbo** property adjoins Wicheeda and covers part of the same carbonatite complex and a cerium-in-soil anomaly. The Wicheeda district comprises several bodies of carbonatite and syenite breccia (syenite clasts in carbonatite matrix) intruded over a 15 km distance. Canadian International Minerals Inc is earning a 75% interest in the Carbo claims from Commerce Resources Inc. Initial work in 2010 consisted of a district-scale airborne electromagnetic, magnetic and radiometrics survey, followed by an auger-assisted soil geochemistry and core drilling (Figure 31). Drilling focused in an area 1 km northeast of that tested by Spectrum Mining Corp; nine holes totalling 1939 m were completed. Minor constituents of the carbonatite include niobium minerals pyrochlore and columbite, and rare earth minerals monazite and bastnaesite (Figure 32).

Bolero Resources Corp holds the extensive **Carbonatite Syndicate** property in the Wicheeda district that adjoins the Wicheeda and Carbo properties. Bolero



Figure 31. Helicopter arrives at the Carbo project, image courtesy of Tor Bruland.



Figure 32. Carbo hole 6 at 149.7 m, cumulate layer of bastnaesite, a REE carbonate mineral, image courtesy of Allison Brand.

shared in the district-scale airborne survey with Canadian International Minerals (see above) and followed up with geochemical and geological surveys.

Zimtu Capital Corp conducted regional exploration in the Rocky Mountain rare metal belt with several different partners. Cathro Resources Corp and Caazador Resources Ltd partnered with Zimtu to conduct field surveys on seven of twelve properties. Zimtu teamed with Dahrouge Geological Consulting Ltd to investigate three of four properties in the Wicheeda district. The Zimtu-Javorsky partnership also holds four properties, three of which were explored.

Mount Bisson is a Rare Earth project owned by Paget Minerals Corporation and located 55 km northwest of Mackenzie. The property is underlain by syenite and pegmatites that intrude and alter high grade metamorphic rocks. Geologic mapping and sampling resulted in finding a new zone 3.5 km from the previously known Laura showing (MINFILE 0930 021). The company reported a sample from the new zone contains 8.64% total rare earth elements. Pegmatite at the Laura showing contains allanite and monazite with significant amounts of lanthanum, cerium, praseodymium and neodymium.

Industrial Mineral Projects in Northern Rocky Mountains

Stikine Energy Corporation mined a 430 tonne bulk sample from its **Nonda** property (Figure 33). Compressors, hand drills, small-scale loaders and a dozer were airlifted to the site, 50 km northeast of Liard Hot Springs, and the rock, Nonda Formation quartz arenite, was transported by helicopter to a staging area on the Alaska Highway (Figure 34). Next, it was transported to Abbotsford where a pilot plant was built to prepare it for



Figure 33. Nonda bulk sample rock being loaded into helicopter bucket.



Figure 34. Staging point for Nonda bulk sample, storage on a prepared platform to avoid contamination.

testing as a frac sand. Frac sand consists of millimetre-size (100 mesh) silica spheres that can be effective, when injected under pressure to hold fractures open so as to liberate natural gas trapped in shale by allowing it to flow to recovery wells. Processing of Nonda quartz arenite produces +70 to -140 (“100 mesh”) material. At time of writing the pilot plant was commissioned and process optimization work was in progress. Currently, frac sand is transported over great distances to shale gas fields in northeast British Columbia. The combination of silica size, quality, gradation, ease of liberation and proximity to end users are critical to the project. Potential users of the Nonda product include the Horn River and Liard shale gas fields within 200 km of the property.

2011 OUTLOOK

Three areas are expected to see a continued high level of exploration activity in 2011. These are:

- 1) the Nechako gold district south of Vanderhoof and Fraser Lake;
- 2) the Quesnel copper-gold porphyry belt between Prince George and Kemess mine, in particular close to the Mount Milligan mine development; and
- 3) the Rocky Mountain carbonatite belt near Wicheeda.

Depending on final results of work in 2010, other areas that are likely to have significant activity are the Fort St. James area for serpentinite-hosted nickel and the Kechika lead-zinc belt.

ACKNOWLEDGMENTS

Bruce Northcote played a major role by preparing the map of exploration projects and surveying companies to collect work and expenditure data; his contribution is greatly appreciated. Marnie Fraser, Katie Ray-Wilks, Alan Day and Vic Koyanagi, Ministry staff in Prince George, provided information on permits and insights on company activity. Bruce Northcote reviewed this document and his constructive comments improved it. The final product benefitted from skilful formatting by George Owsiacki. Several exploration programs were in progress at the time of writing and results for many already completed programs have yet to be released.