# Eaglet Property Revisited: Fluorite-Molybdenite Porphyry-Like Hydrothermal System, East-Central British Columbia (NTS 093A/10W)

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*KEYWORDS*: Eaglet deposit, MINFILE 093A 046, fluorite, fluorspar, celestite, celestine, molybdenite, potassic alteration, pyrochlore, niobium

## INTRODUCTION

The Eaglet property is located on the northern side of Quesnel Lake, 2.5 km east of the North Arm (Fig 1) in NTS area 093A/10W. The identified mineralized zones are located north of Wasko Creek and west of Barrett Creek. Freeport Resources Inc. of Vancouver has owned the property since 1994 when they restaked it as the ‘Q claims’.

Exploration of the Eaglet deposit began in 1946 with the discovery of fluorite in Barrett Creek canyon. The property was briefly examined by Canex Aerial Exploration in 1966. Between 1971 and 1985, Eaglet Mines Ltd. conducted a systematic program of trenching and diamond-drilling, and developed two adits.

Exploration activities ceased at Eaglet when international fluorspar prices suddenly dropped from US$130–210/tonne in 1984 to US$72–115 in 1985, following a fall in molybdenum prices from US$25/kilogram in 1980 to below US$10 in 1983. Fluorspar and fluorite are synonymous terms, with fluorite used more in scientific terminology and fluorspar being a rather technical term in industrial applications.

Given the current strength of commodity prices, with fluorspar at US$180–280/tonne (*Industrial Minerals*, No. 481, October 2007) and molybdenum at US$32.75–34.00/lb of Mo oxide (*The Northern Miner*, November 26–December 2, 2007), an update to the public-domain geoscience knowledge of the Eaglet deposit was warranted.

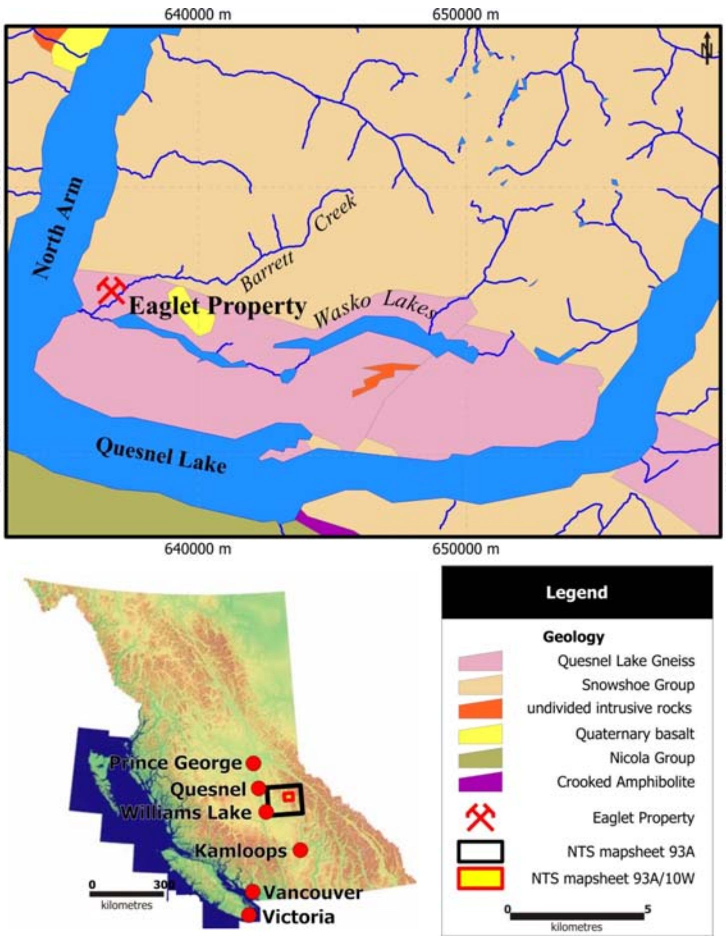

Figure 1. Location of study area, east of the North Arm of Quesnel Lake.

## EXPLORATION OVERVIEW

Mineralization discovered in Barrett Creek canyon was disseminated fluorite and minor celestite, pyrite, galena, sphalerite and molybdenite. In a 1966 report, J.M. McCammon described the discovery zone hostrocks as quartz-feldspar-mica gneiss injected with pegmatite, aplite and granitic rock.

Exploration between 1971 and 1985 included 126 surface diamond-drill holes totalling 19 687 m, together with 9 underground horizontal diamond-drill holes (from adit 1) totalling 1525 m (Fig 2). In addition, two adits, no 1 of 292 m and no 2 of 373 m were driven to test the mineraliza-

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tion underground (Fig 3, 4). This program covered an area 1500 m long and 900 m wide on a south-facing forested slope between elevations of 760 and 915 m. Unfortunately, only a small part of the exploration work was documented and is publicly available in Assessment Reports 5639, 9515 and 10447 filed by Eaglet Mines Ltd. The only geochemical data available from the exploration campaign are incomplete $CaF_2$ assays for 120 of drillholes, 9 of which also have Ag values. The presence of molybdenite has been only briefly mentioned in the *George Cross Newsletter* (1983) and *The Northern Miner* (1984). According to internal Eaglet Mines Ltd. reports, a "good quality fluorspar concentrate" and a saleable $MoS_2$ concentrate were obtained in pilot tests by Kamloops Research and Assay Laboratory Ltd. In 1985, Eaglet Mines Ltd. contracted Peter Read to map adit 2 and relog the on-site core with the objective of conducting a structural analysis of the deposit. Unfortunately, the project was not completed, although 60 manuscript drillcore logs and a map of adit 2 were purchased by Freeport Resources Inc. (Hora, 2005). Preliminary conclusions of this incomplete structural study indicate that the Eaglet mineral zones are folded by late, broad, open upright folds and are locally truncated by faults (P. Read, pers. comm., in Pell, 1992).

When Freeport took control of the deposit in 1994, a variety of pulp samples were stored inside a shed on the property. These included 189 samples from the 1983 diamond-drilling program (holes 83 to 104) and 632 samples of 'ribs' and 'rounds' from adit 2. The diamond-drill hole samples were sent by Freeport for reanalysis of 31 elements by inductively coupled plasma – mass spectrometry (ICP-MS) and $CaF_2$ by wet chemistry (Hora, 2005), and the samples from adit 2 for 34 elements by ICP-MS. In 2005, Freeport also tested samples containing visible molybdenite, collected from the adit 2 muck piles (Fig 5) to document processing suitability of this mineralization type (B. Clark, pers comm, 2005).

## GEOLOGICAL SETTING

The Eaglet deposit is located within Early Mississippian Quesnel Lake granitic orthogneiss (Okulitch, 1985) at its contact with Late Proterozoic biotite-garnet metapelite of the Snowshoe Group (Struik, 1983). Along its structurally modified intrusive northern contact are abundant xenoliths of garnet-biotite metapelite and garnet amphibolite. The deposit area is covered by a continuous blanket of overburden, which varies in thickness from 1.2 to 33.2 m (averaging 11.3 m), as documented from 63 drillhole logs (Hora, 2005). However, contact relationships exposed in the Barrett Creek canyon show an easterly strike and shallow northerly dip (Pell, 1992).

Orthogneiss composition ranges from diorite to granite to syenite (Ferri et al., 1999). The U-Pb zircon geochronometry indicates an age between 375 and 335 Ma (Mortensen et al., 1987). Eaglet mineralization is within the East Quesnel Lake gneiss facies (Fig 4, 6, 7). This facies displays I-type attributes with indications of some assimilation of continental material. Most geochemical characteristics of the East facies point to magma genesis within an arc setting, but its origins are not fully understood (Ferri et al., 1999). Some authors have argued that characteristics of at least parts of the East Quesnel Lake gneiss are consistent with a within-plate or anorogenic setting (Montgomery and Ross, 1989).

Figure 2. Eaglet core storage facility in 2007.

Any geochemical discrimination of Quesnel Lake gneiss near the Eaglet deposit must consider the affects of alteration. The salmon pink colour of gneiss blocks found on muck piles from adits 1 and 2 and in most of the drillcore points to widespread potassic alteration and major-element mobility. In particular, any tectonic discrimination based upon the highly mobile large-ion lithophile elements, such as K, Rb, Sr and Ba, is suspect.

## PETROGRAPHY, MINERALOGY AND CHEMISTRY

Mineralogy was investigated using optical microscopy, X-ray powder diffractometry and electron microprobe microanalytical techniques at the Institute of Geology, Academy of Sciences of the Czech Republic in Prague. Unless specifically noted, analytical data and tables are part of this study.

### *Microanalytical and X-Ray Diffraction Methods*

Microanalytical analyses were made on polished sections with a CAMECA SX-100 electron microprobe using the wavelength dispersive technique. The beam diameter was 2μm with an accelerating potential of 15 kV. A beam current of 10 nA was measured on a Faraday cup. A counting time of 10 s was used for all elements. The standards employed were synthetic $SiO_2$, $TiO_2$, $Al_2O_3$, $Fe_2O_3$ and MgO, and natural jadeite, leucite, apatite, diopside, spinel and barite. The data were reduced using the $\Phi$ ($\rho\zeta$) Merlet correction.

Mineral phases were also identified by X-ray powder diffraction (XRD), using a Phillips X´Pert APD that employs CuKα radiation and graphite monochromator. Scanning speed was set to 1º/min, generator voltage to 40 kV and current to 40 mA.

The ICP-MS analytical results were provided by Vancouver laboratories Min En Labs, Assayers Canada and ACME Analytical Laboratories Ltd.

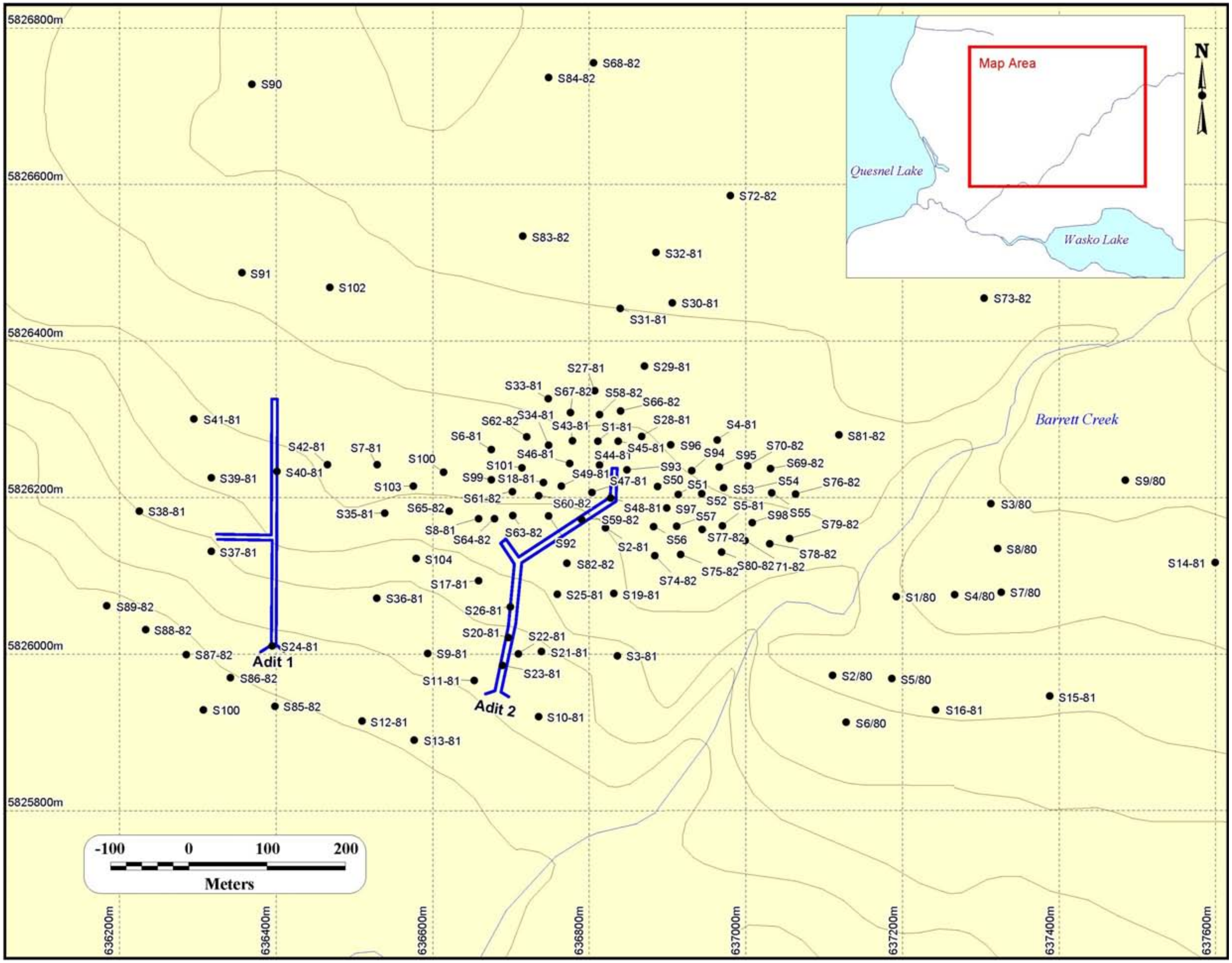

Figure 3. Locations of vertical diamond-drill holes and adits 1 and 2 on the Eaglet property.

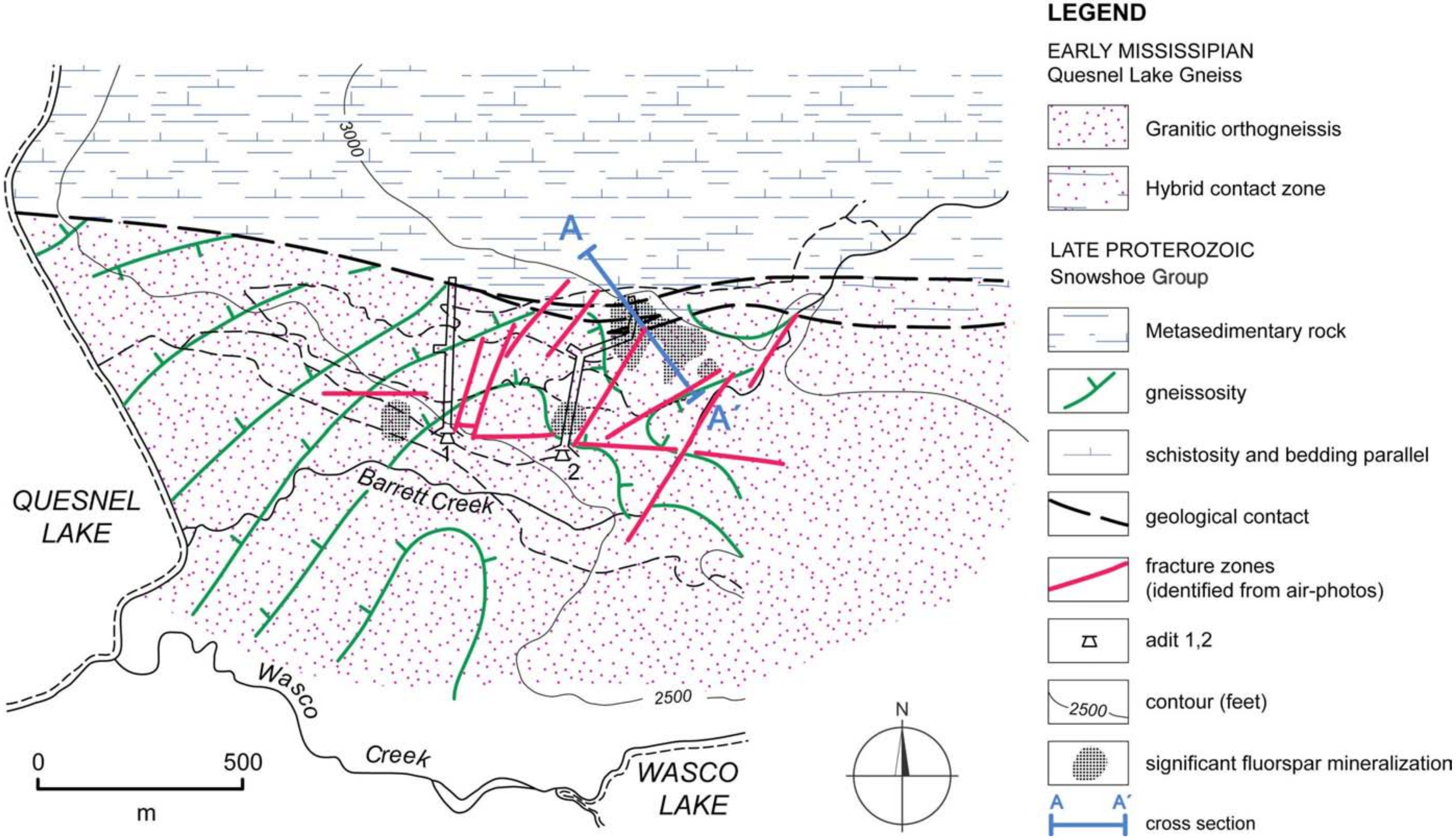

Figure 4. Geology of the property area (*modified after* Pell, 1992), with faults identified from airphotos.

Figure 5. Aerial view of muck piles from adit 2 as they appeared in 2007.

## Petrography

The dominant rock types are salmon pink and light grey gneisses, locally displaying a yellow overprint (Fig 7). They are fine to medium grained and composed of a sucrosic mixture of K-feldspar, albite, quartz and kaolinite group minerals. The rocks are frequently so heavily altered and recrystallized that their gneissic fabric is partially or entirely obscured. Samples of the Quesnel Lake gneiss collected in 2007 present a broader range of rock types than previously recognized: alkaline pyroxenite to leucogranite, aplite and gradations into metapelitic xenoliths.

Mineralogy includes potentially economic minerals fluorite, molybdenite and celestite; dominant rock-forming minerals microcline, albite and quartz; and accessory minerals rutile, pyrite, zircon, sphene, fluorapatite, magnetite and pyrochlore. Secondary minerals resulting from low-temperature hydrothermal alteration are siderite, disseminated very fine grained hematite, calcite, dickite, nakrite, kaolinite 1T with 1Md, and fluorapophyllite.

Figures 8 to 11 document three main stages of physical and chemical changes affecting the orthogneiss:

1) Following silicification and regional metamorphism, the rocks were subjected to albitization and then K-feldspar alteration (microcline) and silicification.
2) Introduction of sulphide minerals ($MoS_2$, PbS and ZnS) may have occurred next, then addition of fluorine and deposition of the oldest generation of fluorite.

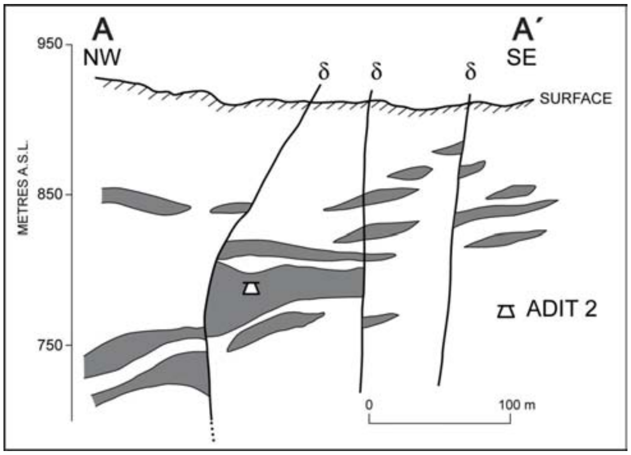

Figure 6. Northwest-southeast section across the mineralized zone, constructed using data projected from drillholes 33, 67, 58, 1, 45, 93, 50, 51, 57, 77 and 80 (*adapted from* Ball and Boggaram, 1985). Faults (δ) interpreted from airphotos.

3) A period of cataclasis ensued, followed by carbonate alteration and addition of multiple generations of fluorite and celestite. Growth of these minerals was accompanied by the alteration products kaolinite, sericite, chlorite and zeolite minerals. Secondary fluorapophyllite was identified by XRD analysis.

Demonstrating that some minerals are remnants of an original protolith is difficult. Only in a few thin sections are the outlines of the original minerals visible where they have been replaced by microcline and their boundaries enhanced by the presence of quartz (Fig 9d). Identification of residual minerals incorporated from the original protolith is less ambiguous (Fig 8b, 10c, 10d). The chemical composition of dominant minerals, identified by XRD as microcline and low albite, is consistent in the samples analyzed (Fig 12; Table 1). Therefore, we interpret these minerals as a product of the same large-scale replacement process. The intensity of feldspar alteration makes distinctions between original rock types uncertain.

A mica sample recovered from aplitic granite intersected in drillhole 43-81 provided an age of 127 ±4 Ma

Figure 7. Sample of East Quesnel Lake gneiss showing pervasive alteration, adit 2.

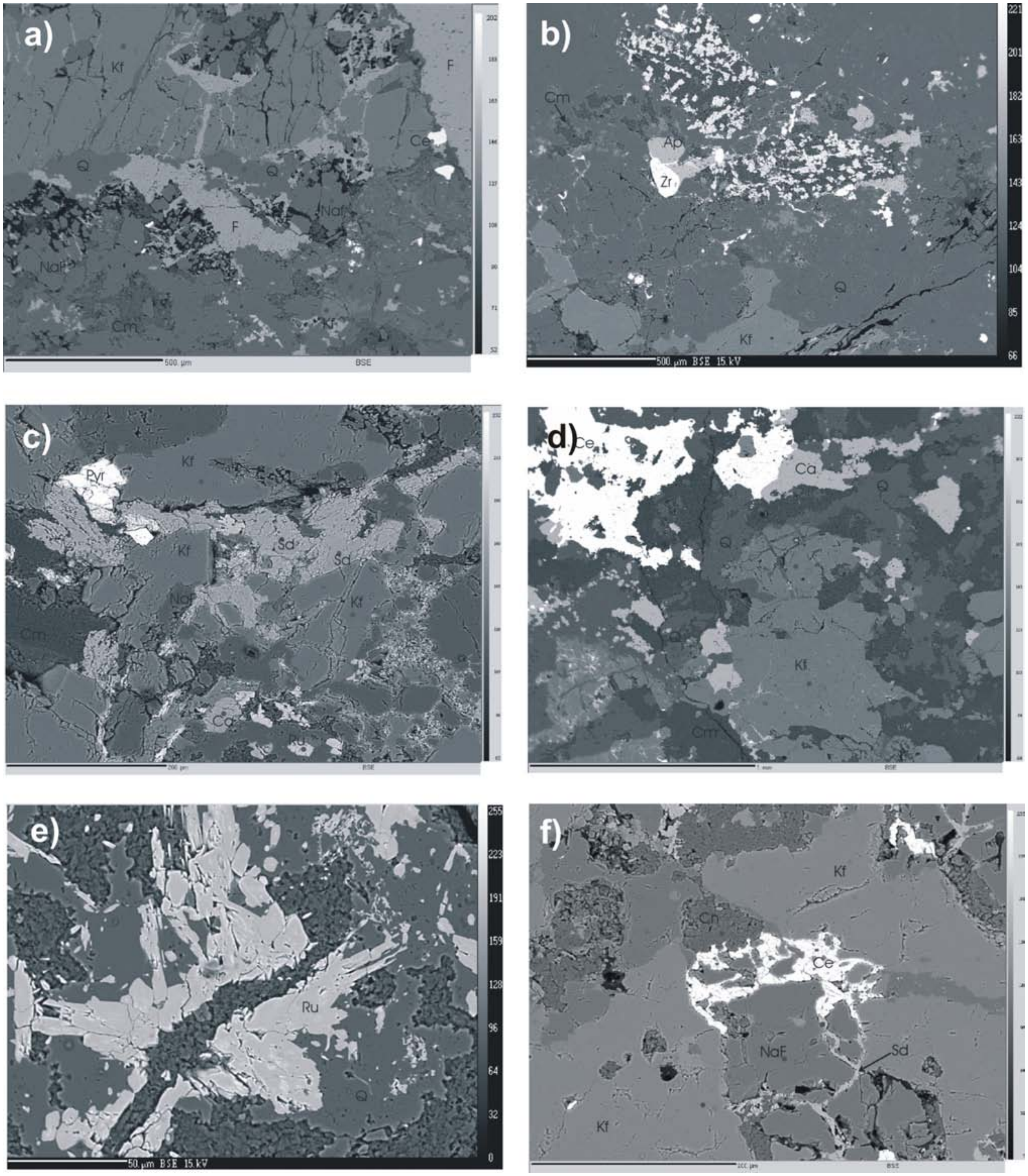

Figure 8. Scanning electron microscope (SEM) photomicrographs showing a) brecciated microcline (Kf) replacing albite (NaF), with fractures in microcline filled by quartz (Q) and fluorite (F); youngest minerals are celestite (Cs) and a clay mineral of the kaolinite group (Cm); b) hydrothermal quartz (Q) replacing microcline (Kf) and enclosing apatite (Ap) and zircon (Zr) with, to the right and up from them, original titanium mineral crystals altered to a mixture of rutile and clay mineral; c) cataclasis of microcline (Kf), which is replacing albite (NaF); intergranular space is filled by siderite (Sd) with pyrite (Pyr) grains; albite contains disseminated grains of calcite (Ca); d) microcline (Kf) cut by microveinlets of quartz (Q) and calcite (Ca); the calcite is partly engulfed by celestite, perhaps indicating replacement of calcite by celestite; in this sample, extensive mats of kaolinite (Cm; type IT) indicate advanced alteration; e) rutile crystals (Ru) enclosed by quartz (Q), with kaolinite (type IT) penetrating both; f) microcline (Kf) replacing albite (Naf), and celestite (Ce), siderite (Sd) and a clay mineral of the kaolinite group (Cn) replacing both feldspars along fractures and grain boundaries.

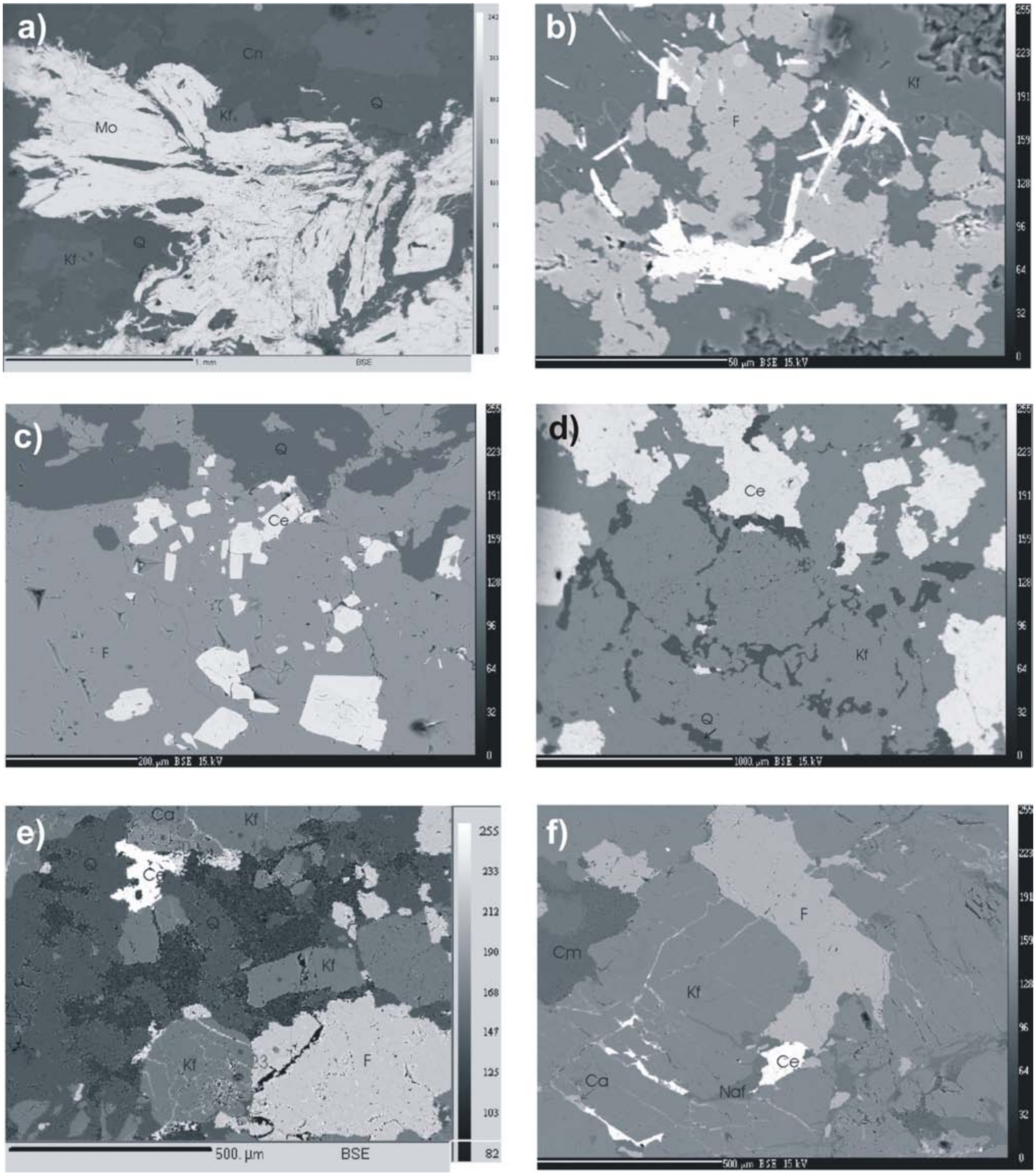

Figure 9. Scanning electron microscope (SEM) photomicrographs showing a) hydrothermal quartz (Q) with an aggregate of molybdenite (Mo) flakes; K-feldspar enclosed in quartz is structurally disordered and is probably a remnant of the original rock; the rock is highly altered, with nacrite present in addition to kaolinite (Cn); b) crystal aggregates of fluorite (F) formed at the expense of K-feldspar (Kf); elongate, prismatic, highly charged (bright) mineral replacing fluorite is an unidentified mineral with high Y, Ce, La and Nd, probably a carbonate related to bastnaesite; c) idiomorphic celestite (Ce) formed at the expense of fluorite (F) and quartz (Q); d) microcline (Kf) replacing the original rock-forming minerals; patchy quartz (Q) outlines the boundaries of replaced minerals and celestite (Cs) replaces both microcline and quartz; e) a highly clay-altered rock specimen, with the oldest mineral being microcline (Kf) and later minerals, in order of paragenesis, being quartz (Q), fluorite (F) and celestite (Ce), all of them replaced by a dark-coloured clay mineral (Cm); f) cataclastic microcline (Kf) replacing albite (Naf), with both being replaced by calcite (Ca), fluorite (F), celestite (Ce) and a clay mineral (probably kaolinite).

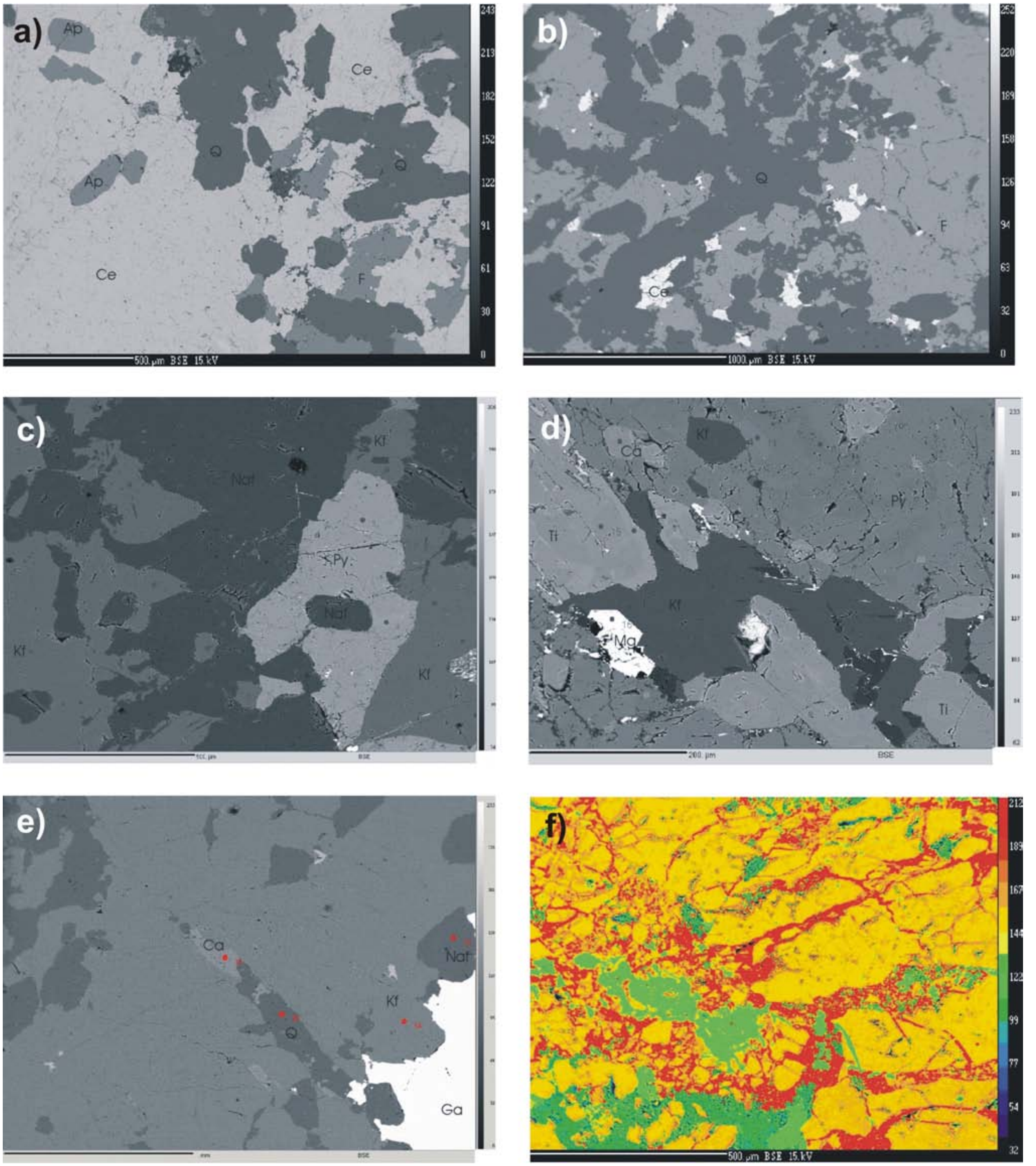

Figure 10. Scanning electron microscope (SEM) photomicrographs showing a) remnants of quartz (Q) and fluorite (F) within celestite (Ce), with apatite (Ap) grains being the only residual minerals from the original protolith; b) quartz (Q) being replaced by fluorite (F), with celestite (Ce) replacing both; c) that the protolith in this sample was probably an alkaline intrusive, as indicated by remnants of original pyroxene (Py) of aegirine-augite composition; albite (Naf) grain is enclosed by the pyroxene and both are replaced by microcline (Kf); d) the same protolith as in 10c; aegirine-augite is associated with magnetite (Mg), sphene (Ti) and calcite (Ca), and late microcline replaces all igneous minerals; e) a quartz (Q) – calcite(Ca) vein with galena (Ga), the galena replacing both microcline (Kf) and albite (Naf); f) colour-enhanced element mapping in a backscatter photomicrograph; microcline is yellow, fluorite is red, siderite is pale green and kaolinite is dark green.

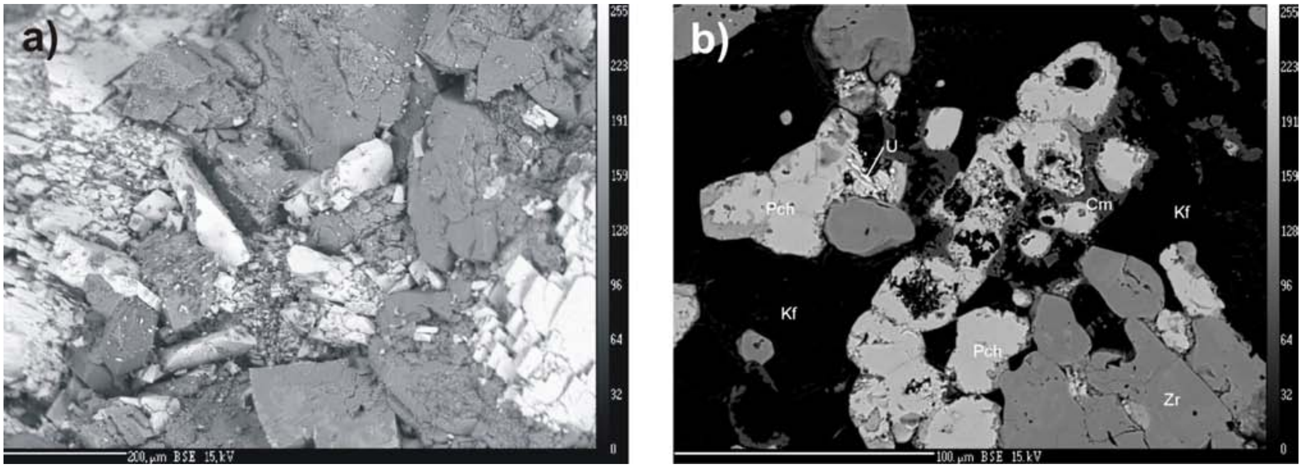

Figure 11. Scanning electron microscope (SEM) photomicrograph showing a) celestite crystals in vugs of carbonate-altered rock; b) aggregates of pyrochlore (Pch) crystals and zircon (Zr) grains enclosed in microcline (Kf) matrix, with the margins of both microcline and pyrochlore corroded and replaced by kaolinite (Cm); bright white inclusions in the pyrochlore are probably uraninite (U).

(Pell, 1992), which is within the range of Cretaceous stocks and dikes with Mo mineralization in the Quesnel and Kootenay terranes elsewhere. A less reliable fission-track date on fluorite from adit 1 suggests an age of formation of 104.6 Ma (Pell, 1992), which is within the same general range.

Alkali feldspars are the dominant minerals of the hostrocks on the Eaglet property. Microcline in anhedral grains with evidence of cataclasis (Fig 8a, 10f) makes up almost 50% of the rocks. It often shows undulatory extinction. Preserved silica rims on original mineral components commonly outline the grain boundaries within the original protolith (Fig 9d). The X-ray diffraction diagrams of microcline confirm its ordered structural state close to the pure theoretical composition. Chemical composition corresponds with very high purity $KAlSi_3O_8$ (orthoclase (Or); Fig 12; Table 1), with only low content of the albite (Ab; max. 4.7%) and celsian (Ca; $BaAl_2Si2O_8$; max. 0.5%) components.

Albite in samples from the Eaglet property is intergrown with quartz, the second most abundant mineral. Petrographic identification of low albite based on polysynthetic and carlsbad-albite twinning was confirmed by XRD. The crystallization of albite preceded formation of microcline (Fig 8c, 8f). Chemical composition (Table 1; Fig 12) corresponds to very pure albite (Ab; $NaAlSi_3O_8$), with only 1.3% Or component and a negligible (0.4%) An content.

Chondrite-normalized rare earth element (REE) abundance patterns for all four samples analyzed are enriched in light rare earth elements (LREE). The LREE pattern is marked by a high $La/Sm_N$ ratio (up to ~180, average ~140), while the content of heavy rare earth elements (HREE) is low but variable ($Gd/Lu_N$ = ~1 on average). All of the analyzed samples have distinctly positive Eu anomalies (Fig 13; Table 2). The samples selected for REE analysis are from mineralized zones high in Sr (>10 000 ppm).

Quartz is present in several mineral associations and several generations that are texturally indistinguishable from each other. The dominant is quartz of hydrothermal origin (Fig 14). Other typical products of low-temperature hydrothermal alteration are siderite (Fig 8c), calcite

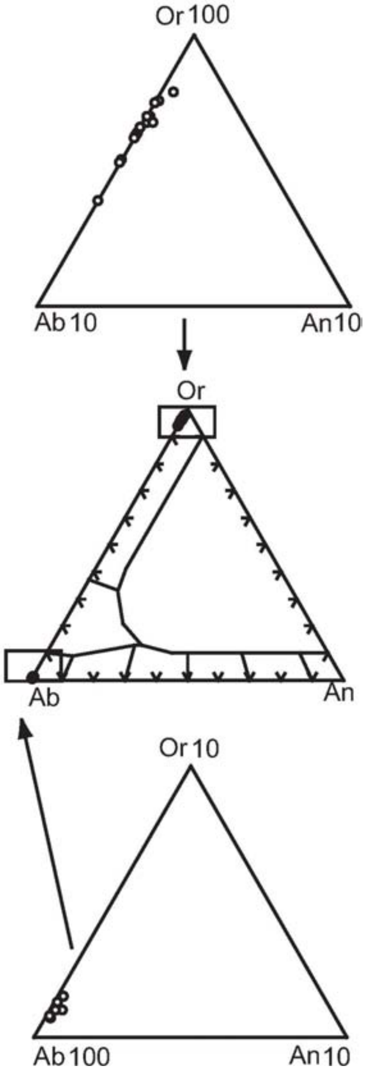

Figure 12. Feldspar minerals from the Eaglet property plotted on an orthoclase-albite-anorthite ternary diagram with expanded orthoclase and albite apices.

TABLE 1. GEOCHEMISTRY OF TYPICAL ROCK-FORMING MINERALS IN EAST QUESNEL LAKE GNEISS FROM THE EAGLET PROPERTY.

| | Microcline | | | Albite | | | Quartz | | | Sphene | | Rutile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 64.09 | 64.49 | 64.88 | 68.88 | 68.33 | 68.36 | 98.62 | 98.80 | 99.77 | 30.61 | 30.22 | 0.41 |
| $TiO_2$ | 0.00 | 0.01 | 0.04 | 0.00 | 0.06 | 0.01 | 0.66 | 0.80 | 0.03 | 31.56 | 33.71 | 89.16 |
| $A_{l2}O_3$ | 17.78 | 18.29 | 18.06 | 19.07 | 19.34 | 19.66 | 0.00 | 0.00 | 0.92 | 1.73 | 1.19 | 0.00 |
| $Cr_2O_3$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| MnO | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.13 | 0.26 | 0.00 |
| FeO | 0.23 | 0.13 | 0.15 | 0.16 | 0.65 | 0.22 | 0.00 | 0.00 | 0.00 | 2.01 | 1.59 | 2.31 |
| MgO | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.31 | 0.00 |
| CaO | 0.01 | 0.01 | 0.00 | 0.09 | 0.04 | 0.06 | 0.00 | 0.03 | 0.03 | 26.45 | 27.13 | 0.18 |
| BaO | 0.23 | 0.13 | 0.06 | 0.00 | 0.10 | 0.00 | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| $Na_2O$ | 0.41 | 0.54 | 0.70 | 11.57 | 11.73 | 11.73 | 0.00 | 0.00 | 0.04 | 0.00 | 0.31 | 0.00 |
| $K_2O$ | 16.65 | 16.54 | 16.37 | 0.17 | 0.12 | 0.16 | 0.00 | 0.02 | 0.06 | 0.04 | 0.01 | 0.05 |
| Total | 99.42 | 100.14 | 100.26 | 100.00 | 100.39 | 100.20 | 99.41 | 99.81 | 99.85 | 92.54 | 94.46 | 92.11 |

| | Magnetite | | Aegirine-augite | | Siderite | | Calcite | | Kaolinite | Muscovite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 1.18 | 0.06 | 52.49 | 51.83 | 1.11 | 0.15 | 0.28 | 0.03 | 47.95 | 45.46 | 45.33 | 45.9 |
| $TiO_2$ | 0.11 | 0.01 | 0.04 | 0.05 | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 | 0.16 | 0.20 | 0.23 |
| $A_{l2}O_3$ | 1.07 | 0.00 | 1.58 | 0.95 | 0.57 | 0.11 | 0.00 | 0.00 | 37.85 | 32.77 | 33.43 | 33.28 |
| $Cr_2O_3$ | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.04 |
| MnO | 0.00 | 0.04 | 2.75 | 1.77 | 0.79 | 1.03 | 0.15 | 0.51 | 0.07 | 0.13 | 0.06 | 0.14 |
| FeO | 83.04 | 89.28 | 16.08 | 23.12 | 50.3 | 50.44 | 0.16 | 1.73 | 0.19 | 5.17 | 5.16 | 5.12 |
| MgO | 0.12 | 0.00 | 5.92 | 4.31 | 5.05 | 4.31 | 0.00 | 0.04 | 0.07 | 0.55 | 0.44 | 0.47 |
| CaO | 0.45 | 0.05 | 14.15 | 10.91 | 1.66 | 1.83 | 54.48 | 54.34 | 0.00 | 0.00 | 0.01 | 0.00 |
| BaO | 0.04 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.12 | 0.02 | 0.00 |
| $Na_2O$ | 0.08 | 0.00 | 5.92 | 7.79 | 0.09 | 0.22 | 0.17 | 0.03 | 0.03 | 0.35 | 0.34 | 0.32 |
| $K_2O$ | 0.04 | 0.00 | 0.01 | 0.02 | 0.06 | 0.01 | 0.02 | 0.03 | 0.00 | 10.54 | 10.55 | 10.38 |
| Total | 86.16 | 89.43 | 99.13 | 99.47 | 59.63 | 58.13 | 55.26 | 56.74 | 86.19 | 95.26 | 95.58 | 95.89 |

(Fig 9f) and clay minerals of the kaolinite group: kaolinite, dickite and nacrite (Fig 8a, 8d, 9a, 9e, 11b).

Magnetite is the most common accessory mineral, forming euhedral to anhedral crystals (Fig 10d). The $Fe_3O_4$ component (87.9–99.0%) is dominant over the ilmenite ($Mg_2TiO_4$) admixture (up to 10.2%). The geikielite ($MgTiO_3$) component is minor (up to 1.3%).

Muscovite is another common accessory in rocks on the Eaglet property (Table 1). Its volume is variable, locally reaching several percent. A genetically important accessory is zinnwaldite, found in centimetre-wide greisen veinlets. Its presence was confirmed by XRD.

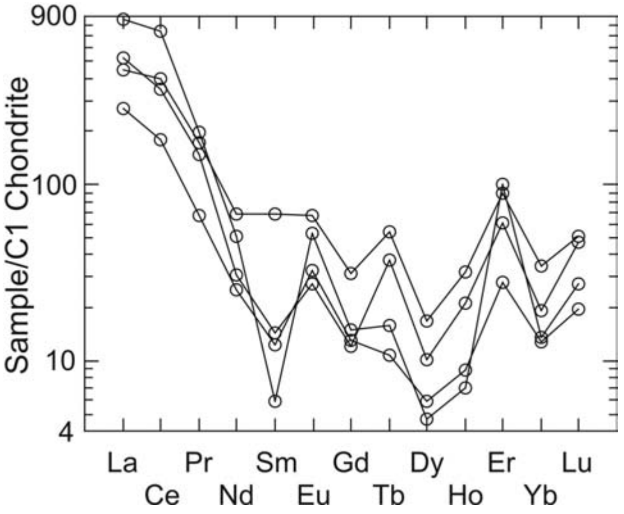

Figure 13. Chondrite-normalized rare earth element pattern of East Quesnel Lake gneiss, Eaglet property.

Other common accessory minerals are rutile (Fig 8b, 8e), sphene (Table 1; Fig 8b, 8e, 10d), fluorapatite (Fig 8b, 10a), pyrite (Fig 8c) and pyrochlore. Pyrochlore commonly occurs as individual grains and crystal aggregates (Fig 11b; Table 3). Pyrochlore, present locally in amounts up to several volume percent, is found in association with microcline, zircon, pyrite and clay minerals of the kaolinite group. Accessory zircon (Fig 8b, 11b), sphalerite and galena (Fig 10e) are rare.

Irregular zones of dark bands within altered East Quesnel Lake gneiss are highly altered amphibolite, garnet amphibolite and pyroxene-bearing rock. Aegirine-augite can enclose euhedral albite crystals and is found in association with microcline, albite, calcite, sphene and magnetite (Fig 10c, 10d, 15; Table 1).

## *Economic Minerals*

Until now, Eaglet had been considered a fluorspar property. In outcrops along Barrett Creek, fluorite showings have been described as disseminated grains, veinlets and scattered veins up to 15 cm thick, and as pods and irregular masses 15 to 20 cm wide (McCammon, 1966). Fluorspar mineralization also crops out in sparse exposures for a distance of 400 m westward from Barrett Creek canyon and again on the lakeshore, 1600 m further west. After an initial search for massive veins was unsuccessful, exploration work targeted lower grade feldspathic zones with fluorite impregnations and a stockwork character (Fig 6,

TABLE 2. RARE EARTH ELEMENT ANALYSES OF EAST QUESNEL LAKE GNEISS HIGHLY ALTERED ZONE, EAGLET PROPERTY. ANALYSES BY ACME ANALYTICAL LABORATORIES LTD.

| Sample | Y (ppm) | La (ppm) | Ce (ppm) | Pr (ppm) | Nd (ppm) | Sm (ppm) | Eu (ppm) | Gd (ppm) | Tb (ppm) | Dy (ppm) | Ho (ppm) | Er (ppm) | Tm (ppm) | Yb (ppm) | Lu (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B 110303** | 26.3 | 124.5 | 212.1 | 14.0 | 14.5 | 2.2 | 1.6 | 2.5 | 1.4 | 2.6 | 1.2 | 10.1 | | 3.3 | 1.2 |
| **B 110313** | 4.8 | 45.2 | 79.9 | 5.7 | 5.5 | 1.6 | 0.5 | 1.3 | 1.0 | | | 4.3 | | 0.6 | 0.3 |
| **B 110315** | 26.4 | 11.0 | 22.0 | 0.5 | 4.9 | | 0.4 | 1.3 | 0.3 | | 0.6 | | | 1.4 | 0.3 |
| **B 110316** | 7.9 | 41.2 | 73.8 | 4.4 | 7.2 | 1.6 | 0.6 | 1.5 | 0.6 | | | 4.4 | | 0.8 | 0.2 |
| **B 110320** | 44.5 | 105.1 | 243.3 | 16.3 | 31.6 | 10.4 | 3.9 | 6.5 | 2.0 | 4.3 | 1.8 | 14.9 | | 5.9 | 1.3 |
| **S92-502** | 18.4 | 35.8 | 62.5 | 4.4 | 5.7 | | 1.2 | 2.2 | 0.2 | | | 0.8 | | 1.5 | 0.3 |
| **S93-520** | 21.7 | 37.3 | 54.8 | 5.0 | 4.6 | | 1.3 | 2.3 | | | | 1.3 | | 1.8 | 0.5 |
| **S97-562** | 27.7 | 206.3 | 449.4 | 18.8 | 24.0 | 0.9 | 3.1 | 3.1 | 0.6 | 1.2 | 0.4 | 16.5 | 0.3 | 2.3 | 0.7 |
| **S98-585** | 22.1 | 103.1 | 173.4 | 10.2 | 12.6 | | 1.5 | 2.1 | | | | 2.2 | | 1.9 | 0.5 |
| **S102-854** | 23.1 | 64.5 | 109.5 | 6.4 | 11.8 | 1.9 | 1.9 | 2.7 | 0.4 | 1.5 | 0.5 | 4.6 | | 2.2 | 0.5 |

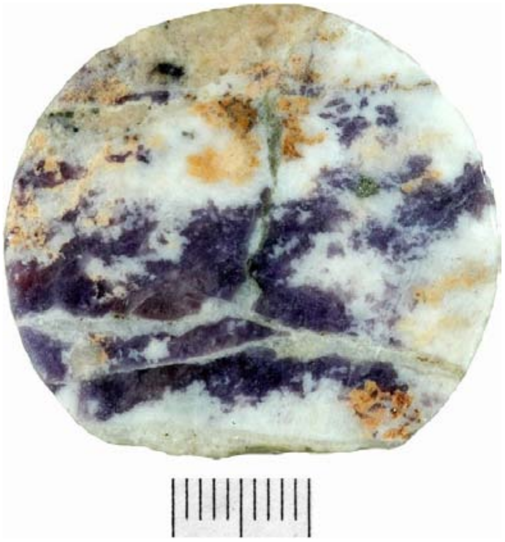

Figure 14. Sample of 'BQ' drillcore showing an early generation of fluorite (Fl) fractured and cemented by quartz (Qtz).

TABLE 3. ANALYSES OF PYROCHLORE, EAGLET PROPERTY.

| | QL A6 | QL A6 | QL C10 | Ql C10 |
|---|---|---|---|---|
| $ThO_2$ | | | 0.36 | 0.31 |
| $TiO_2$ | 8.73 | 8.49 | 8.59 | 8.74 |
| $ZrO_2$ | | | 0.00 | |
| $Nb_2O_5$ | 55.53 | 56.01 | 56.18 | 57.52 |
| $Ta_2O_5$ | 1.28 | 1.25 | 1.19 | 1.25 |
| $U_2O_5$ | 15.42 | 15.85 | 15.45 | 15.59 |
| $Ce_2O_3$ | | | 0.00 | |
| $La_2O_3$ | | | 0.00 | |
| MnO | 0.36 | 0.06 | 0.16 | 0.26 |
| FeO | 1.98 | 2.48 | 3.14 | 2.08 |
| CaO | 6.58 | 5.67 | 3.69 | 5.34 |
| Total | 89.88 | 89.81 | 89.04 | 91.11 |

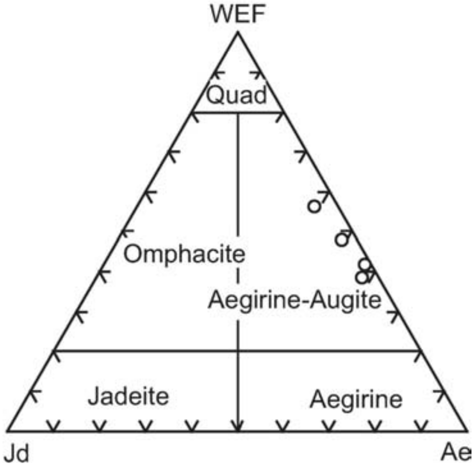

Figure 15. Pyroxene from East Quesnel Lake gneiss on the Eaglet property plotted on wollastonite/enstatite/ferrosilite (WEF) – jadeite (Jd) – aegerine/acmite (Ac) diagram (*after* Morimoto, 1988).

Figure 16. Mineralized breccia in adit 2 of the Eaglet property, showing patchy purple fluorite, flesh-coloured veins of K-feldspar, white celestite and blue-grey silicified zones.

14, 16). Late discovery of molybdenite in adit 2 has not been followed up by work to outline its distribution within the deposit. In 2007, the authors also found molybdenite in a rock pile outside adit 1. Molybdenite is frequently but randomly present along slickenside and gneissosity planes as groups of flakes several centimetres in size (Fig 17). Molybdenite also occurs within quartz veinlets and as grains within crosscutting veinlets of fluorite (Fig 9a). The X-ray diffraction analysis of a laboratory-scale concentration test sample identified two forms of $MoS_2$, the 3R and 2H, in rel-

Figure 17. Sample of coarse-grained molybdenite from adit 2, Eaglet property.

Figure 18. Typical fluorite (Fl) – celestite (Cls) – quartz (Qtz) mineralization from adit 2, Eaglet property. Sample is 5 cm across.

atively similar amounts (Table 4). The widespread presence of celestite in the deposit is unusual. It is commonly found with fluorite and calcite (Fig 11a) and, in some samples, celestite is more common than fluorite (Fig 9c, 9f, 10a). It replaces both fluorite and calcite (Fig 8d, 10f, 18).

The chemical composition of fluorite and celestite, as determined by electrode microprobe microanalysis, is shown in Table 5. Fluorite is very pure, with only 0.25% SrO, irrespective of which of several generations of fluorite is analyzed. The dark purple colour definitely represents a very early fluorite phase. Celestite exhibits zoning of Sr, with an increase from grain centres to the rims (Ba content decreases). Impurities in molybdenite within the mineral phases analyzed by microprobe are below the detection limits of the instrument.

The widespread association of fluorite with feldspar-altered zones at the Eaglet property may suggest a magmatic source for the fluorine component. Specialized magmas with elevated fluorine are usually 'dry', and fluorine migrates from the protolith into the melt only at higher temperatures in the late stages of protolith melting. It may accumulate in the residual melt, lowering the temperature of the granite solidus to 600–650ºC and gradually developing into postmagmatic fluids. Exsolved fluorine-rich fluids may migrate along steep fracture systems into overlying rocks. In a favourable environment, such as a cataclastically deformed feldspathic host, the fluids may react with the host and result in fluorite flooding. A similar process has been described from tin-bearing metallogenic provinces (Tischendorf and Förster, 1990, 1994; Štemprok, 1993).

Mineralized zones at Eaglet can attain thicknesses of up to 30 m (Fig 6). Past exploration efforts at Eaglet have

TABLE 4. MINERAL COMPOSITION OF MOLYBDENITE CONCENTRATE, EAGLET PROPERTY. ANALYSES BY THE MINERAL LAB, INC.

| Mineral name | Chemical formula | Approx. wt % |
|---|---|---|
| Molybdenite(1) | MoS2 | 33 |
| Molybdenite(2) | MoS2 | 22 |
| Quartz | SiO2 | 10 |
| Fluorite | CaF2 | <5 |
| Calcite | CaCO3 | <5 |
| K-feldspar | KAlSi3O8 | <5 |
| Talc | Mg3Si4O10(OH)2 | <10 |
| Kaolinite | Al2Si2O5(OH)4 | <10 |
| Pyrophyllite | Al2Si4O10(OH)2 | <5? |
| Sepiolite | Mg4Si6O15(OH)2.6H2O | <10? |
| Unidentified' | ? | <5 |

(1) '3R' type; also called 'rhombohedral type'

(2) '2H' type; also called 'hexagonal type'

TABLE 5. CHEMICAL COMPOSITION OF FLUORITE AND CELESTITE, EAGLET PROPERTY.

| | Fluorite | | | | |
|---|---|---|---|---|---|
| | gr | v | v | gr | v |
| $SiO_2$ | 0.03 | 0.01 | 0.01 | 0.00 | 0.01 |
| $Al_2O_3$ | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| MnO | 0.00 | 0.02 | 0.06 | 0.00 | 0.00 |
| FeO | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 |
| CaO | 52.30 | 51.34 | 51.61 | 52.95 | 51.81 |
| BaO | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| SrO | 0.17 | 0.25 | 0.02 | 0.23 | 0.01 |
| $SO_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| F | 47.67 | 47.19 | 47.40 | 48.06 | 47.14 |
| $ThO_2$ | 0.01 | 0.02 | 0.06 | | |
| Total | 100.24 | 99.02 | 99.24 | 101.33 | 98.98 |

Abbreviations: gr, individual grains; v, fluorite in veinlets >1 mm

| | Celestite | | | | |
|---|---|---|---|---|---|
| | gr | gr | lgr core | lgr rim | lgr core |
| MnO | 0.00 | 0.00 | 0.06 | 0.05 | 0.00 |
| FeO | 0.07 | 0.02 | 0.07 | 0.01 | 0.01 |
| CaO | 1.21 | 1.13 | 0.05 | 0.12 | 0.17 |
| BaO | 6.36 | 6.59 | 2.75 | 8.57 | 3.96 |
| SrO | 48.81 | 48.16 | 54.08 | 48.11 | 51.97 |
| $Ce_2O_3$ | 0.38 | 0.27 | 0.26 | 0.22 | 0.23 |
| F | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 |
| $SO_4$ | 43.42 | 43.17 | 43.58 | 42.41 | 42.98 |
| Total | 100.44 | 99.36 | 100.86 | 99.50 | 99.35 |

Abbreviations: gr, small grain <1mm ; lgr, larger grain >1 mm outlined eight such zones, four of them described as 'main zones' (Ball and Boggaram, 1985). The special association of higher grade fluorite accumulations with feldspathic zones should not be considered a genetic affiliation (Pivec, 1973). The source of Sr is disputable; however, it is most likely the result of late to postmagmatic fluids penetrating the Snowshoe Group. Such enrichment is not common, but it has been described at other localities, such as the Beauvoir granite in France (Raimboult and Azencott, 1987) and the Ghost Lake batholith in Ontario (Breaks and Moore, 1992). Five more fissure celestite localities in Canada have been listed by Dawson (1985).

### *Discussion*

A large number of ICP-MS analytical results from drillcore and adit 2 samples can be used to demonstrate element associations (or lack thereof) at Eaglet (Hora, 2005). Some previous reports, such as Ball and Boggaram (1985), mentioned the presence of scheelite and wolframite in the deposit. This was not confirmed by our study, and tungsten is practically absent in all laboratory results. However, under UV light, some varieties of apatite, which is very common at the property, have fluorescence similar to that of scheelite, and the two can easily be confused. Tin is also impoverished within the analytical dataset. Lithium is frequently slightly elevated (in the low tens of ppm range). The widespread presence of Sr, frequently in quantities over 1%, is surprising. Only a small set of five samples was analyzed for Nb; all of them had concentrations ranging from tens of ppm to 857 ppm. Lead and zinc are usually elevated in the same samples, mainly in the tens of ppm and only occasionally in the hundreds of ppm (Hora, 2005).

Approximately 25% of samples collected from 13 drillcores from the 1983 exploration program have Mo concentrations ranging from the high tens of ppm to 270 ppm. The high values were found in samples from drillholes 93, 11, 96, 99, 102 and 103 (Hora, 2005). Samples collected from the walls and roof of adit 2, which was driven into the same general area of mineralization, have considerably higher Mo values: more than 15% of 562 samples contain between 100 ppm and 1143 ppm Mo. In particular, adit sections from 240 to 297 m and from 324 to 369 m have consistently high Mo values within this range (B. Clark, pers comm, 2007). Such a difference leads to the question of whether a large volume of samples from 'ribs' and 'rounds', collected during the driving of the adit, gives a more representative result than a sample of 'BQ' drillcore.

There are similarities in mineralogy and geochemistry, such as the presence of potassic alteration, fluorspar, molybdenite, celestite and REE minerals, between the Eaglet property and the well-known Rexpar property (MINFILE 082M 007; Pell, 1992). The presence of pyrochlore with fluorite in a granitic host is also known from the Upper Cretaceous Horsethief batholith, south of Golden (Reesor, 1973).

## SUMMARY

Mineralization at the Eaglet property is interpreted as the product of two superimposed hydrothermal events. Early, pervasive, alkalic feldspar alteration was the product of an alkali sodium and successive potassium-bearing hydrothermal event. These fluids may have originated from a deep-seated, well-differentiated intrusive body. They invaded structurally prepared East Quesnel Lake orthogneiss, perhaps focused on the north flank of the local structural culmination. Extensive feldspar alteration embrittled the gneissic host rocks. Subsequent deformation of the East Quesnel Lake gneiss resulted in brittle dilatancy within the feldspar alteration zones (versus more ductile, unaltered quartz-rich gneiss), thereby forming zones susceptible to percolation by hydrothermal fluids (Fig 6). Successive hydrothermal activity contributed quartz, molybdenite, fluorite, carbonate minerals, and celestite and other accessory minerals, such as a prismatic REE carbonate mineral (Fig 9b). They are interpreted as products of thermal-metamorphic alteration above a differentiated Early Cretaceous granitic body. The large area covered by this aureole indicates a potentially significant size for this unexposed intrusion. The high differentiation of such a deep source is also indicated by several lamprophyre and feldspar porphyry dikes reported from adit 1 (Ball and Boggaram, 1985). Our identification of greisen veinlets with zinnwaldite also suggests a deeper source of alkaline elements. The suspected faults, interpreted from airphotos (Fig 4, 6), are likely premineral faults with postmineral activity proposed to explain the distribution of mineralized zones intersected by drilling, as well as the conduits for hydrothermal fluids and local displacement.

Eaglet Mines Ltd. reported an outlined resource of 24 Mt with an average grade of 11.5% $CaF_2$, including 2 Mt grading 15% $CaF_2$ (Ball and Boggaram, 1985). An estimate of the Mo resource has not yet been attempted.

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