The Pattison Creek pluton – a mineralized Casino Intrusion made bigger with gamma rays

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Abstract

Results from an airborne gamma ray and magnetics survey in the Dawson Range in west-central Yukon indicate that the Pattison Creek pluton may be larger than currently mapped. Ground follow-up indicates that the pluton is approximately three times larger than originally shown. This pluton is a member of the Casino Intrusions – a unit identified as being genetically associated with copper-molybdenum mineralization and as such is considered a good exploration target. Examination of the pluton indicates that it is a highly fractionated, epizonal stock composed primarily of granite and alkali feldspar granite with later phases of peraluminous muscovite-bearing alaskite and aplite. Microthermometric and isotopic data indicate that mineralizing hydrothermal fluids are of low salinity, and depleted in deuterium and $\delta^{18}O$ relative to values typical of magmatic waters. The gamma-ray survey shows it to have among the highest U and Th values in the survey area (> 3.0 and 15 ppm respectively).

Résumé

Les résultats fournis par un levé gamma et magnétique aéroporté réalisé dans le chaînon Dawson dans le centre-ouest du Yukon révèlent que le pluton de Pattison Creek est plus étendu que ne l'indiquent les cartes actuelles. Le suivi de terrain révèle en effet que le pluton est environ trois fois plus volumineux qu'on ne l'avait indiqué jusqu'ici. Ce pluton fait partie des intrusions de Casino - unité considérée comme étant génétiquement associée à des minéralisations de cuivre-molybdène et constituant donc une cible d'exploration propice. L'examen du pluton révèle qu'il s'agit d'un stock épizonal très fractionné composé essentiellement de granite et de monzonite quartzique accompagnés de phases tardives d'alaskite et d'aplite à muscovite. Le levé gamma indique en outre que le pluton présente certaines des plus hautes teneurs en U et en Th de la région prospectée (>3,0 et 15 ppm respectivement).

INTRODUCTION

Regional-scale, airborne gamma-ray and magnetics surveys provide a quantifiable indication of rock types and alteration. This type of survey is particularly useful in unglaciated regions with deep weathering where the surface material (colluvium) is the same as the underlying bedrock. Such a survey was recently conducted in the Dawson Range (Fig. 1) with the ultimate goals of: 1) improving the existing geological maps of the region (e.g. Johnston and Shives 1995) and 2) providing data with which exploration efforts could be focused. The largest mineral deposit in the region is the Casino copper-molybdenum-gold porphyry (675 million tonnes of 0.25% Cu, 0.02% Mo, 0.48 g/t Au).

The Pattison Creek pluton (62°02'N; 138°38'W, not the same as the Pattison pluton of Lynch and Pride (1983)) is a small felsic intrusion located approximately 27 km south of the Casino deposit and 130 km west-northwest of Carmacks in the western Dawson Range. The pluton is one of several which together comprise the Casino Intrusions – a suite of leucocratic quartz monzonite to granodiorite stocks identified by Payne et al. (1987) as the intrusive unit most closely associated with the Casino Cu-Au-Mo porphyry deposit. Several small occurrences of this unit were mapped in the central Dawson Range of west-central Yukon (Payne et al., 1987). The Pattison Creek pluton was identified by Payne et al. as being geologically and chemically similar to the Casino deposit. As such, the Pattison Creek pluton is a prospective target for Casino-style mineralization and indeed is known to host an occurrence of copper and molybdenum.

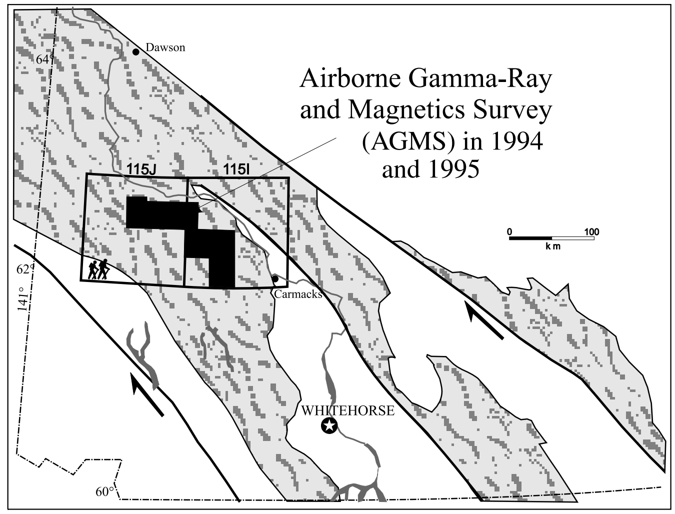

Figure 1. *Location of the airborne geophysical survey in the Dawson Range of west-central Yukon. The survey area is entirely within the Yukon-Tanana Terrane (patterned).*

Results from an airborne gamma-ray and magnetic survey of the Dawson Range indicated a discrepancy between the geophysical response and the currently mapped distribution of the Pattison Creek pluton. The geophysical anomalies suggest that the Pattison Creek pluton may be larger than mapped. If so, a greater area is prospective for the occurrence of Casino-style mineralization.

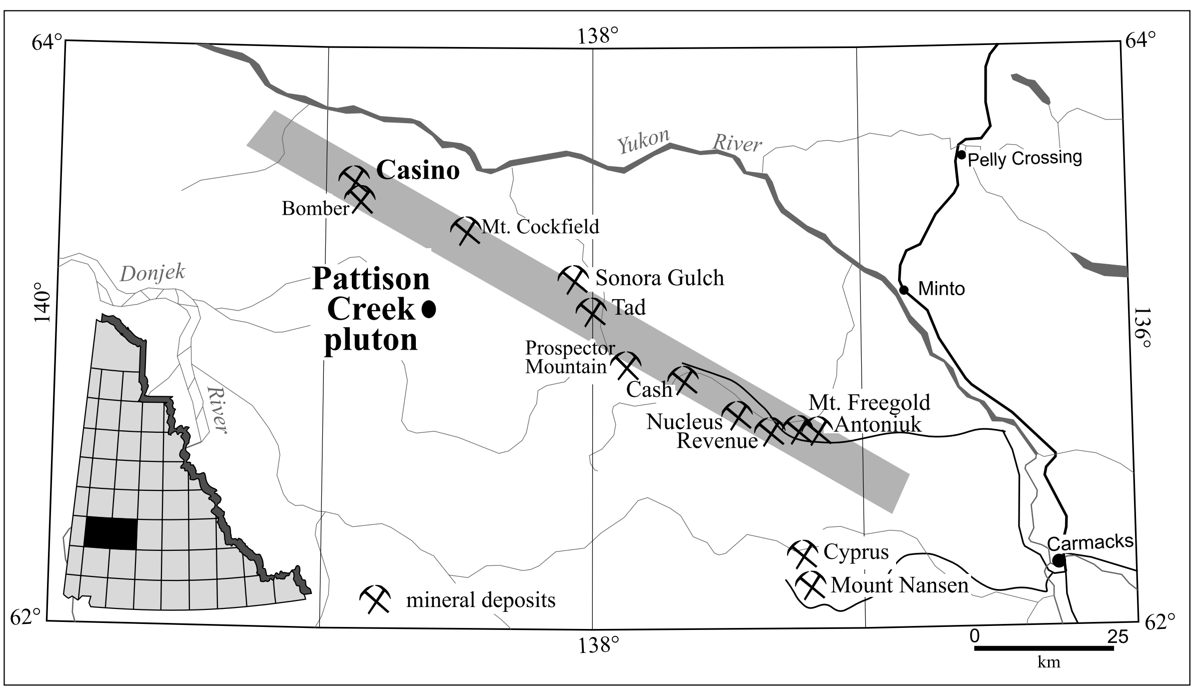

Figure 2. *Location of the Pattison Creek pluton with relation to the Dawson Range mineral belt (shaded). The significant mineral deposits of the region are also shown.*

Ground follow-up, combined with detailed examination of the gamma-ray signature results in a new map of the Pattison Creek pluton. The new map indicates that the areal extent of the Pattison Creek pluton at least triples. This paper reports on new observations made during brief field visits in 1996 and 1997.

LOCATION

The airborne geophysical survey covered the equivalent area of six 1:50 000 map areas that comprise the mineral deposit-rich regions of the Dawson Range in west-central Yukon (Fig. 1). The surveys (Geological Survey of Canada 1994, 1995) consisted of approximately 9000 line-kilometres of helicopter-borne gamma-ray and magnetics. Flight lines were flown north and south and were spaced 500 m apart

The Pattison Creek pluton was covered by the westernmost survey (Geological Survey of Canada 1994a). The pluton is located near the headwaters of Pattison Creek in the central Dawson Range in southeastern NTS map sheet 115J/10. The property is accessible by helicopter from Carmacks, approximately 130 km west-northwest of Carmacks (Fig. 2). Alternatively, the Casino airstrip, located 27 km north of Pattison Creek, can be used as a staging area.

GEOLOGICAL SETTING

The Pattison Creek pluton is within the western portion of the Yukon-Tanana Terrane. It intrudes the contact between the Yukon-Tanana Terrane metamorphic rocks and the mid-Cretaceous hornblende-biotite granodiorite of the Dawson Range Batholith. The metamorphic rocks are dominated by Nasina assemblage black, carbonaceous quartzite, tan-coloured quartzite, and amphibolite with lesser felsic orthogneiss. The Dawson Range batholith is composed of coarse-grained biotite-hornblende granodiorite.

The Pattison Creek pluton is one of a series of plutons in the Casino Intrusive suite which also include small bodies at Casino and Idaho Creek. Mapping by Payne et al. (1987) showed the pluton as a north-trending elliptical body with maximum dimensions of 4 x 2 km and a surface area of 4.5 km^2.

PATTISON CREEK PLUTON

The Pattison Creek pluton it is generally light weathering and recessive with few outcrops (Fig. 3). The roof of the pluton is exposed in two places suggesting a flat-topped pluton with an exposed cupola. The sharp eastern contact may be truncated by a north-trending normal fault.

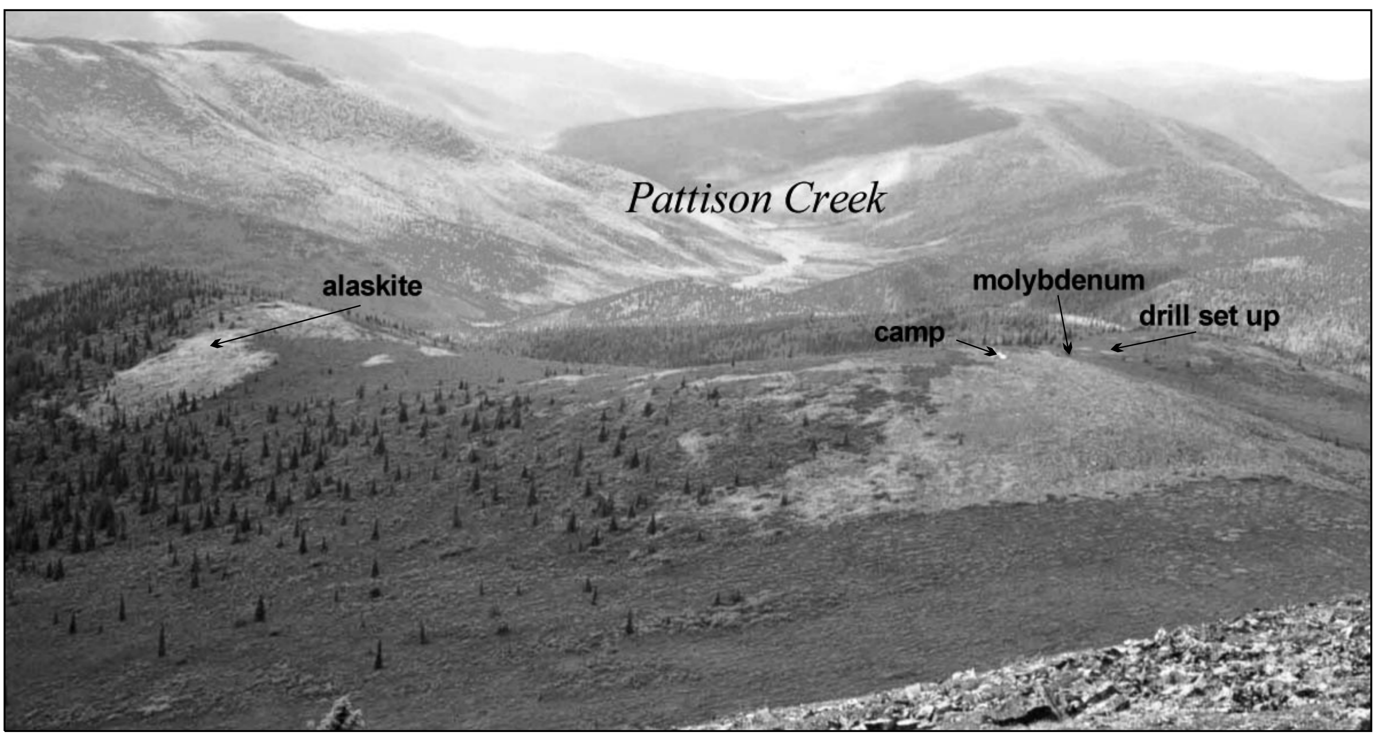

Figure 3. *Looking southwest down Pattison Creek. The Pattison Creek pluton is the recessive weathering ridges in the foreground. The background rocks are predominantly Yukon-Tanana Terrane metamorphic rocks.*

The Pattison Creek pluton is lithologically and texturally diverse. It is variably composed of granite, quartz monzonite, and alaskite with associated aplite.

The dominant phase is light grey, weathering porphyritic granite with a sucrossic matrix (80%) composed of approximately equal amounts of fine- to medium-grained intergrown quartz and alkali feldspar with subordinate (5%) but important biotite (Fig. 4a). Euhedral phenocrysts of plagioclase (8%, up to 6 mm), quartz (5%, up to 8 mm), biotite (2%, up to 4 mm), hornblende (0.5%, up to 4 mm) and rare muscovite were observed. In weakly altered samples, ragged biotite is locally pseudomorphed by muscovite and opaque oxides.

The alaskitic phase is subordinate and composed of white to buff weathering, equigranular, medium- to coarse-grained granite alaskite with approximately 30% quartz, 25% plagioclase, and 35% late alkali feldspar and no biotite (Fig. 4b). This unit has rusty weathering cavities that likely result from the oxidation of sulphide minerals. Some phases contain up to 10% primary muscovite. Secondary, finer-grained muscovite appears to be locally replacing alkali feldspar. This phase is shows evidence of high temperature phyllic alteration (muscovite, pyrite) locally.

The alaskitic phase has an associated aplite phase which is composed of equigranular, sucrossic and fine-grained, intergrown and graphic textured quartz, alkali feldspar and plagioclase with some coarser-grained quartz phenocrysts (Fig. 4c). Muscovite is typically coarser grained and comprises up to 15% of the rock. The alaskite also forms a few late sills which cut the other phase.

All phases contain small miarolitic cavities up to 2 mm in diameter. Zircon was observed locally in thin section. Late quartz-alkali feldspar pegmatite dykes also cut the pluton.

A northerly-trending series of 2-5 m wide, fine-grained andesitic to dacitic dykes are common in the country rocks surrounding the Pattison Creek pluton (Unit 15b of Payne et al., 1987). Locally they are sparsely porphyritic with phenocrysts of plagioclase and hornblende. The pluton is cut by at least one of these dykes, thus confirming a younger relative age.

GAMMA RAYS

An investigation of results from the airborne gamma-ray and magnetics survey from the Dawson Range indicates that the region underlain by the Pattison Creek pluton is high in K, Th and U, and low and flat in magnetics (Fig. 5). These are the expected responses from an evolved and fractionated, quartz-rich magmatic rock. Furthermore, the Th/K ratio is very high and the U/K and U/Th ratios are low. However, the region defined by these variables is not coincident with the currently mapped pattern. As a result, the area was mapped at 1:25 000 scale, despite the paucity of outcrop. New mapping indicates that the pluton is exposed over an area of 16-18 km^2 (Fig. 6).

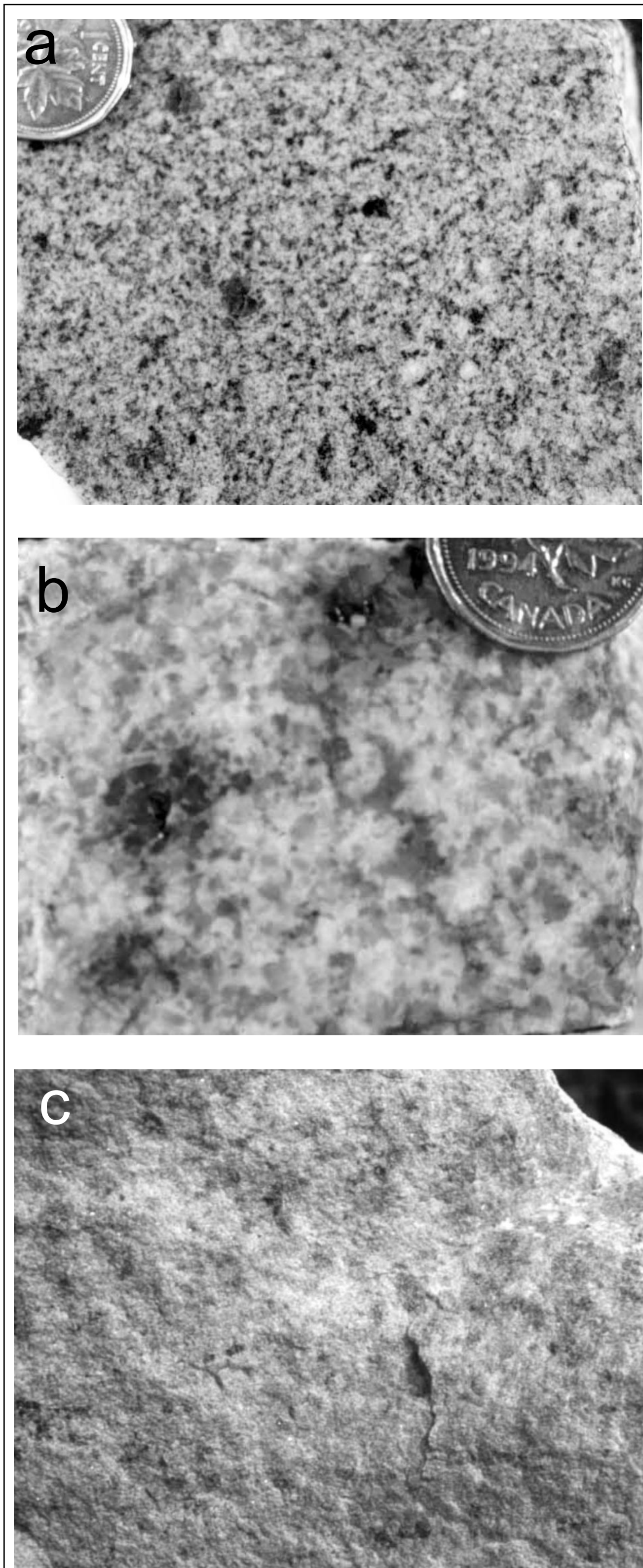

Figure 4. *a) photo of granite phase; b) photo of alaskite phase. The dark spots are oxidized sulphide minerals; c) photo of aplite phase.*

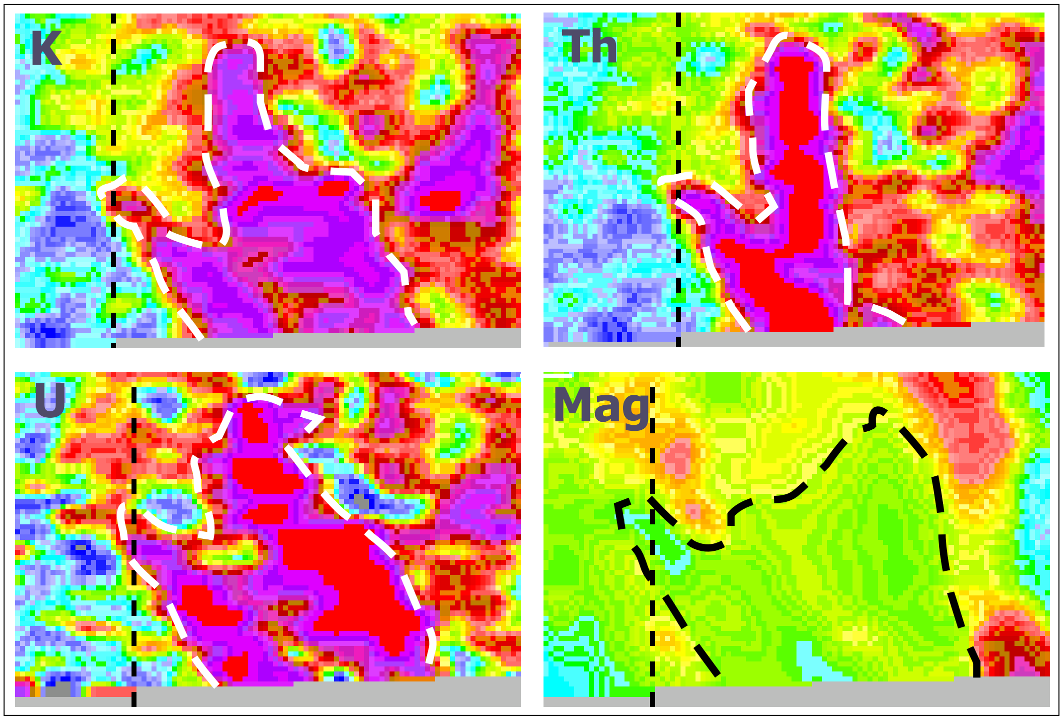

Figure 5. Detail from Geological Survey of Canada (1994a) airborne geophysical survey of the Pattison Creek area indicates regions (defined by dashed line) of high K (>2.0%), high Th (>12 ppm), high U (>1.8 ppm) and low magnetics (<-49 gammas). These anomalous patterns are not coincident with the map pattern of the Pattison Creek pluton. The vertical dashed line on all the figures is 138°40′W longitude.

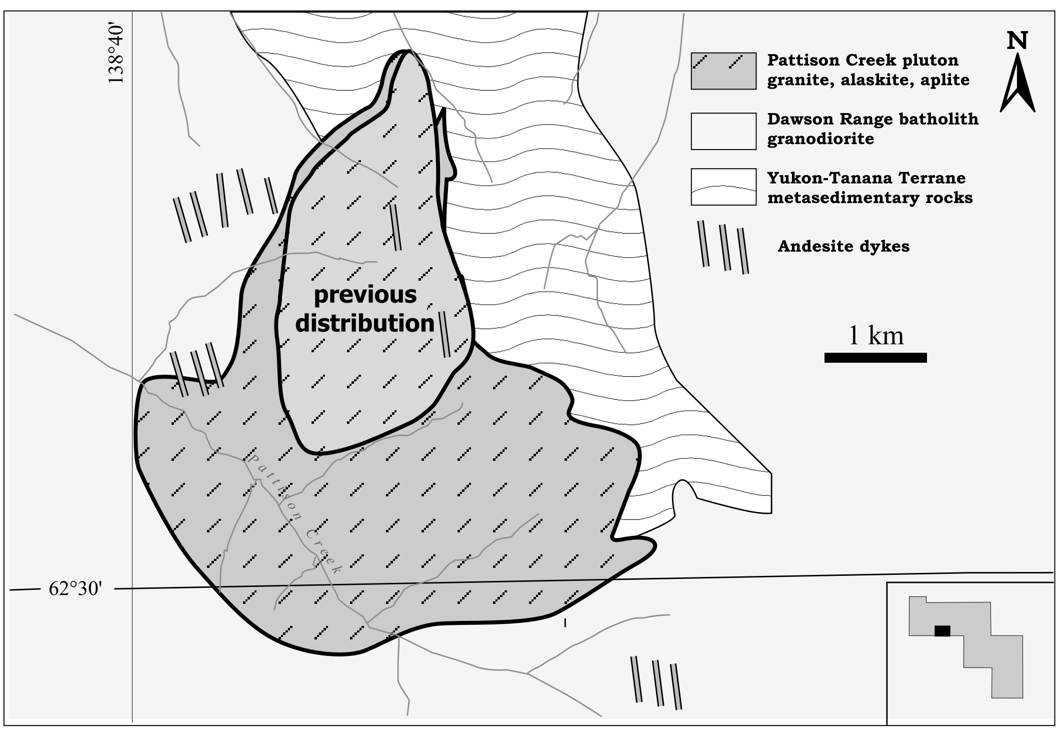

Figure 6. General outline and geology map of the Pattison Creek pluton showing the enlarged area based upon field mapping guided by the radiometric survey results. The new map reflects an extent based on ground follow-up of the geophysical results. Inset map shows location within AGMS survey area in west central Yukon (see Fig. 1).

GEOCHEMISTRY

Preliminary geochemical analyses of samples from the Pattison Creek pluton support their identity as granite, perhaps best referred to as alkali feldspar granite (Fig. 7a). Plots on Shand's chemical index support the mineralogical data (muscovite-bearing, no hornblende) which indicate a classification of peraluminous (Fig. 7b). SiO_2 values range from 73-78% and K_2O values vary between 3 and 5.5%. The elevated U and Th values are supported by the geochemical analyses with values between 6 and 20, and 9 and 25 ppm, respectively (Fig. 8). These values have higher U contents than averages for the upper crust or low Ca granites, but are lower than values from the Surprise Lake batholith near Atlin, B.C. — a pluton that is recognized as being uraniferous (Ballantyne and Littlejohn, 1982).

MINERALIZATION

The Pattison Creek pluton hosts an occurrence of molybdenum and chalcopyrite. The PATT mineral occurrence (Yukon Minfile 115J 087) was discovered and staked in 1974 by Amoco Canada Petroleum Company who followed up copper and molybdenum silt anomalies with a soil survey and mapping. Minor molybdenite and chalcopyrite was discovered in narrow quartz veins cutting quartz monzonite and alaskite. An IP survey was undertaken the following year. In 1976, four holes totalling 565 m were drilled from three set-ups to test Mo-in-soil anomalies and weak IP responses. All holes encountered molybdenite mineralization with lesser chalcopyrite, and pyrite blebs in quartz veins. Minor amounts of disseminated molybdenum was also discovered in aplitic phases. Copper graded 0.01% throughout but molybdenum values varied between holes with grades of up to 0.059% MoS_2 over 52 m (DDH PATT-1) and 0.037% MoS_2 over 160 m (DDH PATT-3). Alteration has been discovered so far weak phyllic and limited argillic.

Porphyry copper deposits are typically associated with a gamma-ray response that includes elevated K and a low Th/K ratio. This is typically in response to potassic alteration in the core of porphyry system. Despite the high potassium values, the Pattison Creek pluton does not show a low Th/K region. Instead it contains the highest ratios on the entire map sheet with values between 8 and 9.5, including the location of the known molybdenum occurrence (Fig. 9). This largely reflects the highly fractionated nature of the magma which results in Th-enrichment.

FLUID CHEMISTRY

Stable isotope and fluid techniques have been used to investigate the chemistry of the hydrothermal fluids associated with molybdenum and chalcopyrite mineralization. Analyses were performed at the University of Alberta in the Earth and

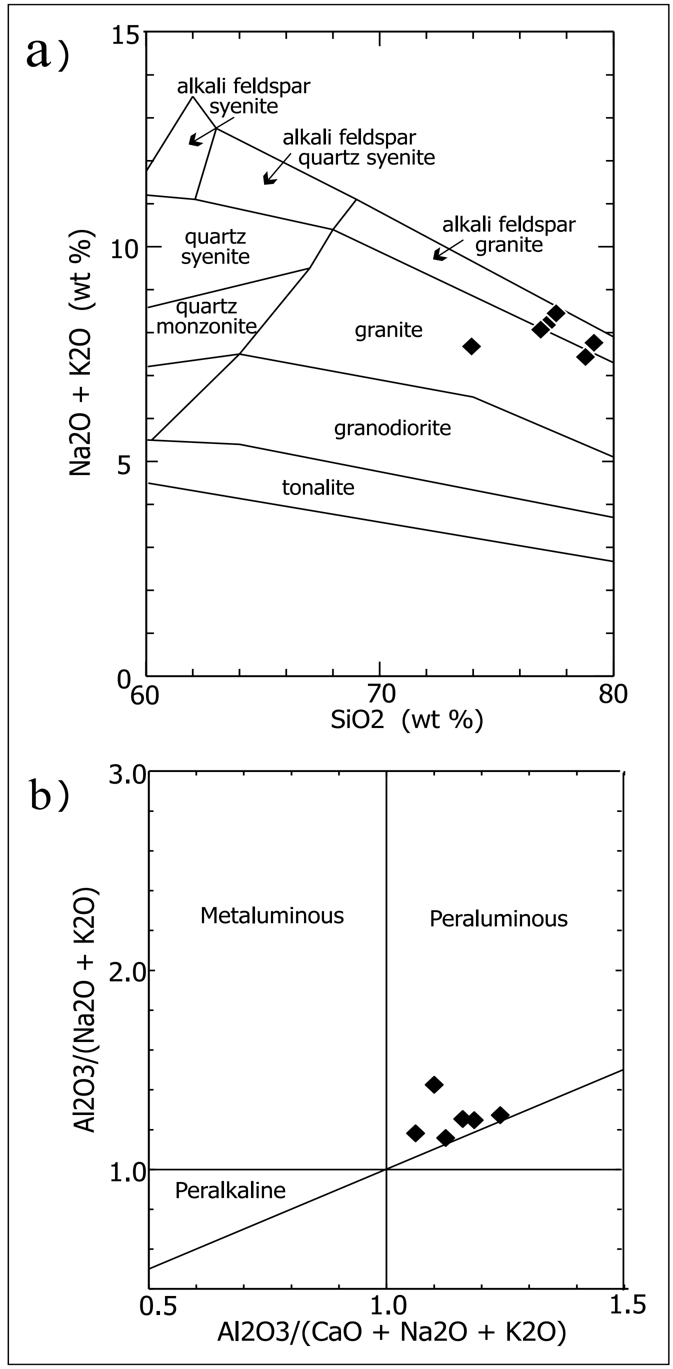

Figure 7. a) *Total alkali – silica plot which shows that rocks from the Pattison Creek pluton lie in the true granite or alkali feldspar granite fields (as defined by Middlemost, 1985).* ***b)*** *Shand's index shows samples to plot in the peraluminous field as expected due to the presence of muscovite. Geochemical data are presented as anhydrous and were obtained by standard x-ray methods from XRAL Laboratories. Dataset is expected to be published in an upcoming Bulletin.*

Atmospheric Sciences Stable Isotope and Fluid Inclusion Facility. Data presented below are from quartz vein samples from DDH PATT-3. The analytical precision for stable isotope analyses (1σ) are ±0.2‰ for oxygen and ±5‰ for hydrogen, and for mircothermometric measurements are ±0.2°C for freezing and ±2°C for heating.

Quartz veins consist of molybdenite, with minor chalcopyrite and pyrite mineralization. Silicification, sericite, and chlorite comprise the alteration assemblage bordering the quartz veins. Optical observations of quartz fluid inclusion chips at room temperature identified only one fluid inclusion type which is small (up to 10 µm), two phase, liquid-rich inclusions. Microthermometric analysis were conducted on four quartz veins. Final ice melting (T_{fm}) temperatures are between -0.1° to -2.9°C, with a mean value of -1.79±0.69°C (n = 67). Using the expressions of Bodnar and Vityk (1995) T_{fm} values indicate salinities between 0.18 and 4.8 wt.% NaCl eq. The fluid inclusions homogenize by vapor bubble disappearance at temperatures between 187° and 340°C, with a mean value of 240.5±30.97°C (n =67).

Oxygen and hydrogen isotope ratios determined from the same quartz veins yield $\delta^{18}O$ values between 5.5 and 6.4 ‰ (SMOW), with a mean value of 6.1±0.41 ‰ (n = 4). Waters from fluid inclusions yield δD values between -147 and -168 ‰ (SMOW), with a mean value of -155.5±8.96 ‰ (n = 4).

Microthermometric and isotopic data indicate hydrothermal fluids are of low salinity, and depleted in deuterium and $\delta^{18}O$ relative to values generally accepted as magmatic waters (Talyor and Sheppard, 1986). The fluid chemistry characteristics from the Pattison Creek molybdenum occurrence are more similar to fluids encountered in epithermal vein systems (e.g. Freegold Mtn., McInnes et al., 1988; Mt. Nansen, K. Smuk, pers. comm.), and are dissimilar to fluids from Dawson Range porphyry systems (e.g. Casino, Mt. Nansen, Cash; Selby, unpub. data).

GEOCHRONOLOGY

The age of the Pattison Creek pluton is uncertain. Payne et al. (1987) mapped the Casino Intrusions as being mid-Cretaceous in age, largely on the basis of numerous *circa* 100 Ma K-Ar age dates from similar rocks at the Casino deposit (Godwin, 1975a). Godwin (1975a,b) thought that the quartz monzonite phases at Casino were a phase of the mid-Cretaceous Klotassin (Dawson Range) batholith and largely co-genetic with mineralization. Subsequently, the Casino intrusions were included in the Prospector Mountain plutonic suite by Johnston (1995) who assigned them a Late Cretaceous age on the basis of *circa* 70 Ma age dates from the Prospector Mountain and Mount Pitts areas. It is most probable that the Pattison Creek pluton is mid-Cretaceous in age but Ar-Ar geochronology is currently underway.

DISCUSSION/CONCLUSIONS

Evaluation of airborne gamma-ray and magnetics survey information indicates that the Pattison Creek pluton is likely larger than previously mapped. Its greater extent is confirmed by revision mapping which indicates new boundaries of the pluton. The textural and lithological diversity of the pluton, in

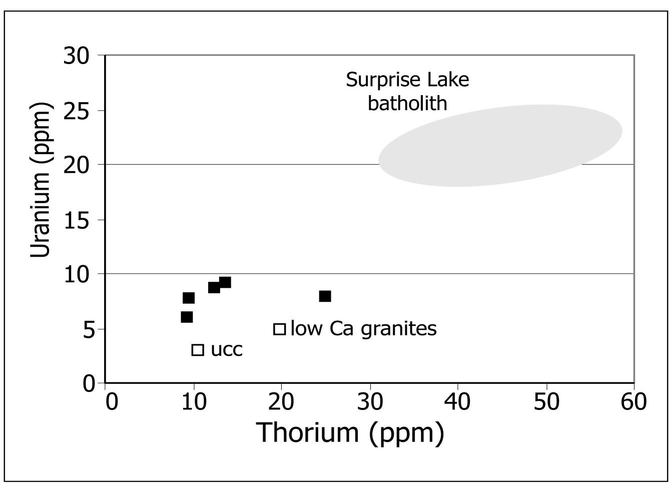

Figure 8. *U vs. Th plot for samples from the Pattison Creek pluton. Range of Surprise Lake batholith values from Ballantyne and Littlejohn (1982); ucc=upper continental crust average from Taylor and McLennan (1985); low-Ca granite values from Turekian and Wedepohl (1961).*

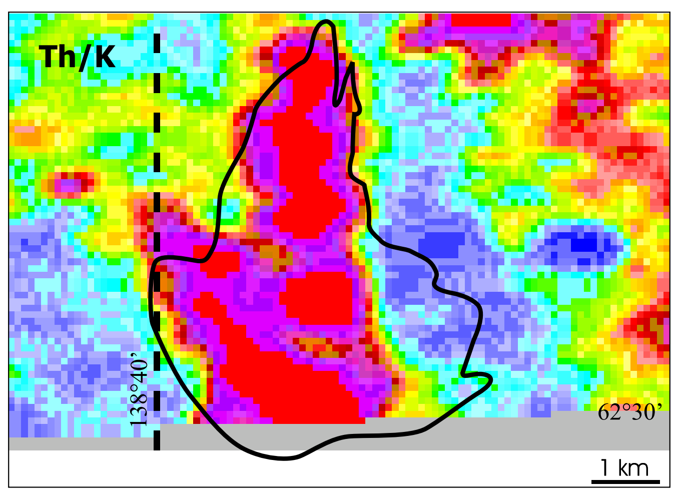

Figure 9. *Detail from Geological Survey of Canada (1994a) of the Pattison Creek area showing region of elevated Th/K ratio with new outline of the Pattison Creek pluton and the location of molybdenum mineralization. The southeast corner of the pluton has a low value due to well exposed Yukon-Tanana Terrane metamorphic rocks on a west-facing slope.*

combination with small miarolitic cavities, indicates probable intrusion at a relatively high level in the crust. The presence of muscovite, aplite and alaskite, in combination with high K, Th and U values determined from the airborne survey, indicate that the Pattison Creek pluton is highly fractionated. This is confirmed by preliminary lithogeochemistry that confirms its classification as a peraluminous alkali feldspar granite. Plutons in southwest Alaska with similar geochemistry (e.g. Donlin Creek) are associated with gold mineralization (Bundtzen and Miller, 1997). It is unlikely that the Pattison Creek pluton has been evaluated in that context.

Molybdenum mineralization may result from evolved fluids associated with the magmas, but the stable isotopes suggest a more dilute fluid influenced by meteoric waters. Age dating studies are currently underway to determine the age and affiliation of the pluton.

Airborne gamma-ray and magnetics surveys allow a new level of geological understanding in regions of poor outcrop exposure. Survey results from the Dawson Range and have proven themselves to be useful in this regard (this study and Johnston and Shives, 1993), but in all cases require ground follow-up.

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