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PRELIMINARY INVESTIGATIONS INTO THE STYLE, SETTING AND TIMING OF URANIUM MINERALIZATION, JACQUES LAKE DEPOSIT, CENTRAL MINERAL BELT, LABRADOR

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ABSTRACT

Ongoing investigations within the Central Mineral Belt (CMB) of Labrador are aimed at determining the style, setting and timing of the diverse uranium mineralization that is present throughout the region. This summary presents preliminary data on the Jacques Lake uranium deposit, which is one of the most significant new discoveries in the CMB. Uranium mineralization within the Jacques Lake deposit is associated with the development of actinolite–magnetite–carbonate ± biotite ± pyrite veining, within a regionally developed high-strain zone. This high-strain zone is associated with a pronounced aeromagnetic anomaly that forms part of a larger regional mineralized corridor, spanning some 30 km in length. Mineralization at the Jacques Lake deposit resembles that described from the better known Michelin deposit in some respects, including the association of hematite alteration and sodium-metasomatism with uranium mineralization. The veining associated with mineralization at the Jacques Lake deposit appears to have pre-deformational or syn-deformational timing. A new U–Pb age of 1801 ± 0.9 Ma for an undeformed, post-mineralization quartz–feldspar-porphyry dyke provides a younger age limit for uranium mineralization.

INTRODUCTION

REVIEW

The felsic metavolcanic rocks of the Aillik Group have long been known to host uranium mineralization (*e.g.*, Beavan, 1958; Gandhi, 1978; Gower *et al.*, 1982), and they presently include the most significant resource of low-grade uranium mineralization known in Labrador. The largest occurrence is at the Michelin deposit, where BRINEX defined an historical resource of approximately 18 million pounds of U_3O_8 prior to the collapse of the uranium market in the early 1980s (Sharply, 1980). Subsequent exploration activity, since 2004, once again focused on the Michelin deposit, and additional drilling carried out by Aurora-Energy has greatly expanded the deposit, identifying a total resource of 103 million pounds of U_3O_8 (Cunningham-Dunlop and Lee, 2008).

During this renewed exploration, airborne radiometric surveys were completed over large tracts of land within the Central Mineral Belt (CMB) of Labrador, and defined many significant radiometric anomalies. Although many areas were covered by more primitive surveys in the 1960s and 1970s, the more sophisticated instrumentation identified stronger anomalies where only subtle responses were detected earlier. The most prominent example occurs at the Jacques Lake deposit, where previous exploration identified a zone of radioactivity in the late 1950s. This zone of mineralization produced assay results of up to 0.7% U_3O_8 and was known as the McLean Lake showing. Mineralization was, however, considered to be of limited extent. Subsequent airborne radiometric surveys identified a significant regional anomaly, and more detailed exploration has now identified a uranium resource that is, at least, as large as that defined for Michelin in the 1980s. The Jacques Lake deposit was first drilled by Aurora-Energy in 2005 and is now known to contain a 43-101 compliant resource, of approximately 17 millions pounds of U_3O_8 (Cunningham-Dunlop and Lee, 2008).

Of the new discoveries within the CMB, Jacques Lake is the most significant in terms of its contained resource (Figure 1). This deposit is one of several uraniferous zones that sit within a mineralized trend of regional extent. The Jacques Lake deposit shares several characteristics with the Michelin deposit, including some similar associated alteration styles and similar metavolcanic host rocks. Recent studies carried out by the first author have focused on constraining and characterizing the timing and style of mineral-

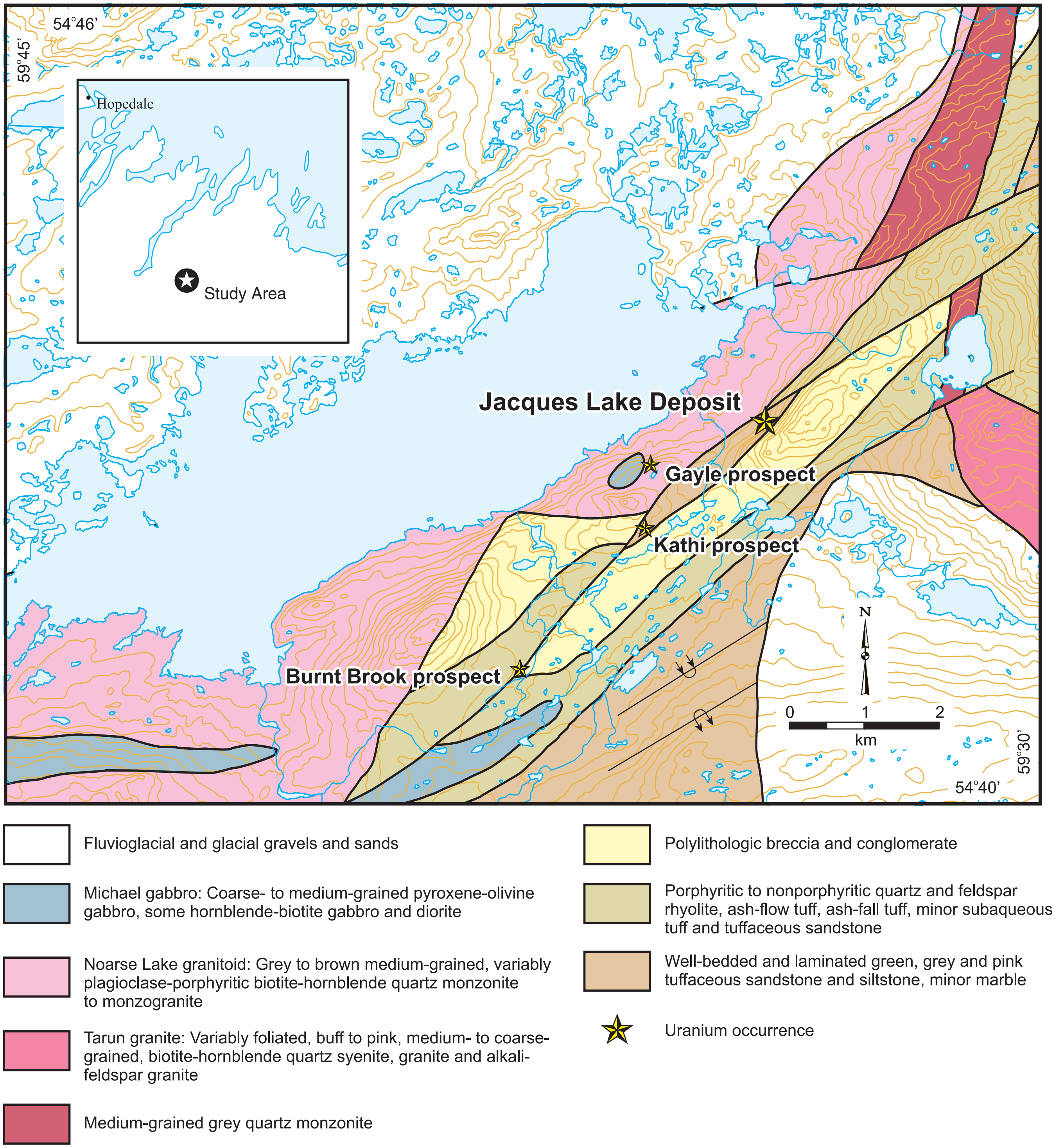

Figure 1. *Location map of the Jacques Lake deposit and surrounding uranium prospects. Modified after Gower* et al. *(1982) and Kerr (1994).*

ization within the Jacques Lake deposit. This paper summarizes the current understanding of the alteration, mineralization and the relative timing of each, and presents new U–Pb data that constrains the minimum age of these events.

PREVIOUS WORK

The original McLean Lake showing, now known as the Jacques Lake deposit, was initially discovered in 1956 during regional-reconnaissance prospecting carried out by BRINEX (Morrison, 1956). The outcropping mineralization, then referred to as J-2, was exposed along the northern face of a ridge immediately south of the lake, then known as McLean Lake. In 1967, a property-wide airborne survey was flown using two separate techniques. The fixed-wing radiometric survey failed to produce a significant radiometric anomaly, but a helicopter-borne survey produced a strong response immediately over the showing (Beavan and Meyer, 1968). This prospect was partially evaluated during field reconnaissance in 1967 when the area was trenched and blasted; the best grab sample obtained during this period assayed 0.2% U_3O_8 and a 500 lb. bulk sample assayed 0.054% U_3O_8 (Beavan and Meyer, 1968). During this time, various ground geophysical surveys were carried out, including a ground magnetometer survey. This survey indicated that a magnetic low was associated with the radiometric highs along the north side of the ridge (Beavan and Meyer, 1968). This observation contrasts with those of more recent surveys, which show magnetic highs associated with development of magnetite alteration and uranium mineralization (Wilton and Cunningham-Dunlop, 2006).

During a limited re-evaluation of the outcropping mineralization and the surrounding immediate area in 1978, an average of 0.3% U_3O_8 was produced from twelve samples taken from outcrop and float, with the highest assay value of 0.7% U_3O_8 being obtained from the outcrop samples (McClintock, 1978). The prospect was again re-examined in 1980 when additional trenching and sampling was carried out; average assays values collected at that time were 0.02% U_3O_8 over 1 m and the highest assay returned 0.074% U_3O_8 over 1 m (Darch, 1981). Further mineral exploration in the region identified several other zones of anomalous radioactivity along strike from the Jacques Lake deposit; they include the Andrew zone to the northeast and the Gayle and Kathi zones to the southwest (Figure 1; McClintock, 1978; Darch, 1981). Drilling was recommended as follow-up work subsequent to the 1980 field program, but this was never completed.

REGIONAL GEOLOGY

The Jacques Lake deposit is located approximately 17 km southeast of Kaipokok Bay, immediately southeast of the eastern end of Jacques Lake (Figure 1). Uranium mineralization is hosted within volcanic rocks of the regionally extensive Paleoproterozoic Aillik Group, which comprises an upper greenschist- to lower amphibolite-facies, volcano-sedimentary sequence (Bailey, 1979; Gower *et al.*, 1982; Hinchey, 2007). Volcanic rocks within the Aillik Group are dominantly felsic volcanic rocks including rhyolite, felsic tuff, and related volcaniclastic rocks and tuffites (Gower *et al.*, 1982; Hinchey, 2007). A sample from a weakly cleaved felsic ash-flow tuff from Michelin Ridge, approximately 30 km along strike to the southwest (Figure 2), produced an age of 1856 ± 2 Ma (Schärer *et al.*, 1988). In the region of White Bear Mountain, situated some 13 km southeast of the Jacques Lake deposit, an undeformed quartz–feldspar-porphyry unit produced an age of 1807 ± 3 Ma (Schärer *et al.*, 1988). The significance of this age, relative to felsic volcanism, has been questioned, and several authors have suggested that in light of the widespread, synchronous *ca.* 1800 Ma igneous activity in the area, it is likely that the dated porphyry is related to the younger magmatic event, not Aillik Group volcanism (Sinclair *et al.*, 2002; Hinchey, 2007). The Aillik Group is intruded by various foliated and non-foliated *ca.* 1800 Ma intrusions related to the transpressional phases of the Makkovikian orogeny (Kerr *et al.*, 1992; Ketchum *et al.*, 2002).

The volcanic rocks in the region of the Jacques Lake deposit are situated along the eastern flank of a large non-foliated granitoid intrusion and display variable degrees of deformation and regional-scale folding (Bailey, 1979). In the region surrounding the Jacques Lake deposit, supracrustal rocks typically display a weak to intense northeast-trending penetrative fabric that generally dips moderately to steeply southeast. Regional metamorphism is generally interpreted to range from upper greenschist- to lower amphibolite-facies with chlorite, actinolite, biotite and epidote commonly developed within the supracrustal sequences (Bailey, 1979). The main period of deformation that affects these rocks is attributed to the Makkovikian orogeny, but the area was likely also affected by the subsequent Grenvillian Orogeny on at least a local scale (Bailey, 1979; Gower *et al.*, 1982).

The felsic to intermediate metavolcanic rocks of the Aillik Group are the dominant hosts to uranium mineralization within the eastern portion of the CMB. On a regional scale, the rhyolitic rocks within the Jacques Lake region contain average uranium values of approximately 10 ppm (Bailey, 1979); however, values of up to 47.5 ppm uranium were reported from rocks within the area of the Michelin deposit (Evans, 1980). These volcanic rocks have previously been considered to be the source of the uranium in models for the mineralization within the region, which was attributed to synvolcanic hydrothermal processes (*e.g.*, Evans, 1980; Gower *et al.*, 1982). Recently, a close link to metamorphic and/or metasomatic processes has been suggested for these deposits (*e.g.*, Sparkes and Kerr, 2008). From a regional perspective, several uranium deposits, including the Michelin deposit at the southwestern end of the trend, the Mustang Lake and Aurora River occurrences near the central portion, and the Jacques Lake deposit at the northeastern end of the trend, are situated along a pronounced northeast-trending aeromagnetic anomaly (Figure 2). The northern portion of this trend, which runs roughly

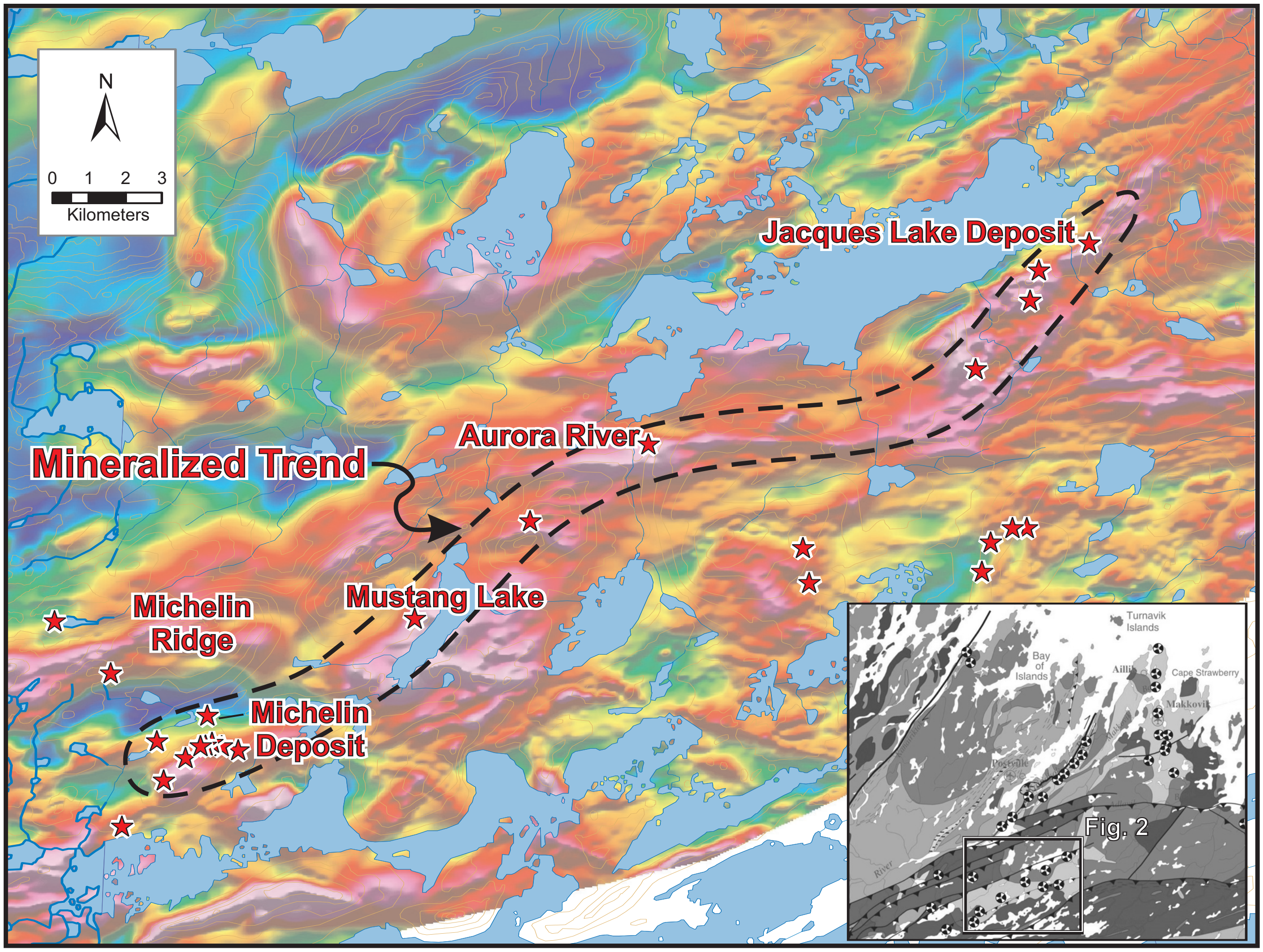

Figure 2. *Location of select uranium occurrences along the regional mineralized trend underlain by the associated aeromagnetic anomaly.*

parallel to the southeastern side of Jacques Lake, has been termed the 'Aurora Corridor' and is interpreted as a regional shear zone (Aurora-Energy Resources, press release, September 11, 2007).

GEOLOGY AND MINERALIZATION

LOCAL GEOLOGY

The Jacques Lake uranium deposit is poorly exposed at surface, consisting of sparse outcrop along the northern face of a steep northeast-trending ridge above the eastern end of Jacques Lake. The host rocks were originally misinterpreted as quartzites due to their fine-grained nature and recrystallization due to the strong degree of deformation within the region (Beavan and Meyer, 1968). These rocks are now reinterpreted as being primarily volcanogenic in origin, with minor interbedded volcaniclastic material (Bailey, 1979; Darch, 1981; Wilton and Cunningham-Dunlop, 2006). Within the deposit, uranium mineralization is hosted by dark purple to grey-green, aphanitic to moderately porphyritic, magnetite-bearing rocks interpreted to have originally been intermediate ash-flow tuffs. The ash-flow tuffs are affected by a variably developed penetrative fabric that is locally intense and mylonitic (Plate 1). This fabric is attributed to the main regional fabric and is interpreted as a regional D_2 event within the Aillik domain (Hinchey and Laflamme, *this volume*).

The mineralized ash-flow tuffs are, in turn, structurally overlain to the southeast by a poorly sorted, generally matrix-supported, cobble to boulder polymictic conglomerate containing clasts of predominantly volcanic detritus; this unit forms the hanging wall to the deposit (Figure 3). The most intense shearing within the region of the deposit is focused along the contact between the ash-flow tuff and the conglomerate, with both the contact and the penetrative fabric dipping moderately to steeply toward the southeast.

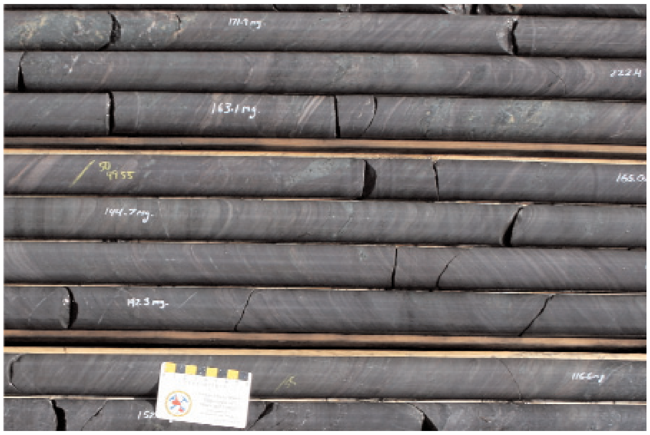

Plate 1. *Strongly deformed ash-flow tuff displaying the development of an intense penetrative fabric.*

Plate 2. *Locally developed folding of the penetrative fabric within the ash-flow tuff sequence.*

Metre-scale folding of the volcanic rocks has been noted throughout the region with fold axes locally overturned to the southeast (Bailey, 1979); the variable orientation of the penetrative fabric in drillcore combined with local observations of metre-scale folding indicates that the penetrative fabric displays some rotation due to a later deformational event (Plate 2; Figure 3). To the north of the current study area, these regional isoclinal folds (F_2) refold outcrop-scale F_1 folds and have been interpreted as being synchronous with the development of the penetrative fabric (D_2) and subsequently refolded during an F_3 event, marking the final stages of transpression associated with the Makkovikian orogeny (Hinchey, 2007; Hinchey and Laflamme, *this volume*). The conglomerate unit is locally noted to contain clasts of albitized intermediate volcanic rocks, and thus is interpreted to postdate the deposition of the underlying ash-flow tuffs and perhaps postdate the development of uranium mineralization (Cunningham-Dunlop and Lee, 2008).

At the base of the ridge, the ash-flow tuff sequence and accompanying uranium mineralization are bounded to the west by undeformed, medium- to coarse-grained felsic to intermediate intrusive rocks that form the footwall to the deposit. These rocks display sharp intrusive contacts with the adjacent ash-flow tuff, locally displaying well-developed chilled margins; also evident are the emplacement of frequent granitoid dykes within the ash-flow tuff proximal to the main body of the intrusion. Within the centre of the deposit, a very distinctive quartz–feldspar-porphyry dyke locally intrudes mineralized ash-flow tuff, providing a younger age constraint on the development of uranium mineralization (*see* page 90). This unit varies in width from 3 to 26 m in drillcore, and contains distinctive cm-scale white feldspar phenocrysts that are commonly zoned; the core of these zoned feldspar phenocrysts locally incorporates a small percentage of mafic minerals (Plate 3). The porphyry dyke is generally undeformed and crosscuts the main penetrative fabric developed within the host volcanic rocks (Plate 4), but locally develops a weak to moderate fabric related to a younger deformational event. This unit is also spatially associated with a more mafic-dominated phase, which is generally developed along the margins of the quartz–feldspar-porphyry dyke, and locally contains xenoliths of the porphyry dyke as well as fragments of the zoned feldspar phenocrysts. Several generations of mafic dykes are observed within the mineralized zone and include both deformed and undeformed dykes.

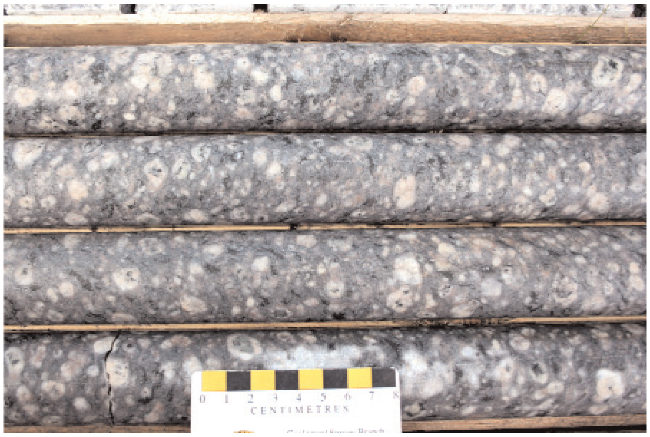

Plate 3. *Coarsely porphyritic quartz–feldspar-porphyry dyke containing distinct, cm-scale, zoned feldspar phenocrysts.*

MINERALIZATION AND ASSOCIATED ALTERATION

Since the initial discovery at Jacques Lake in 1956, uranium mineralization has been noted to occur in association with hematite alteration of the host volcanic succession. Alteration and uranium mineralization are closely associated with a zone of relative high strain; however, observations

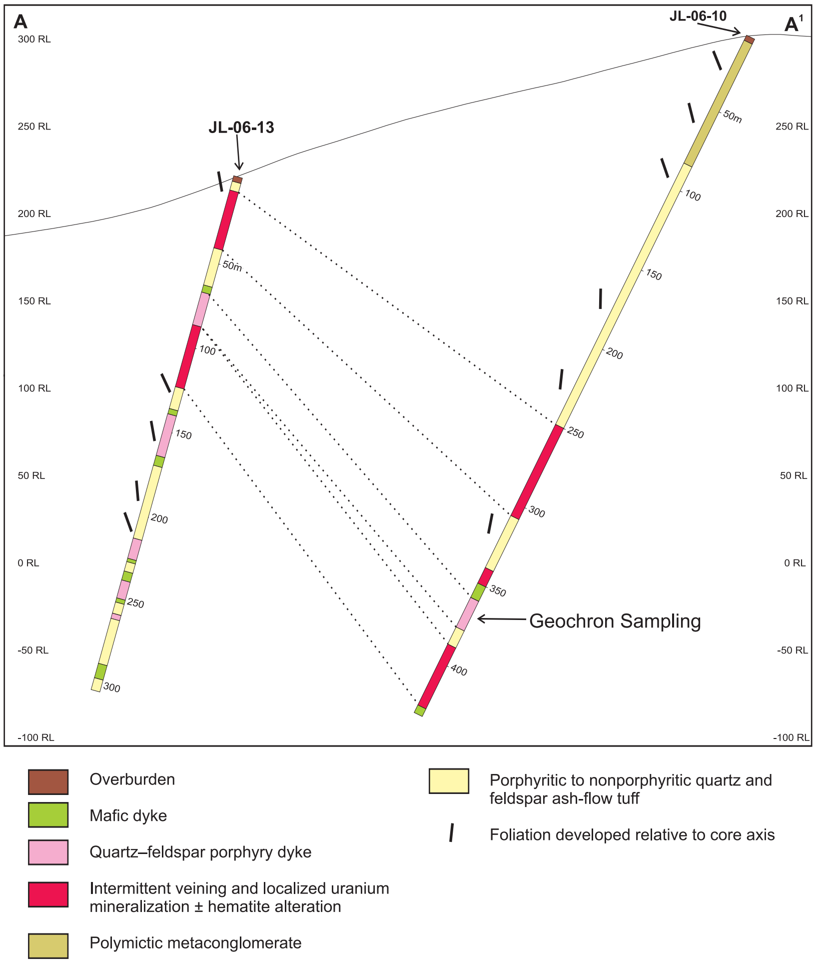

Figure 3. *Simplified diagram showing the location of uranium mineralization and the main lithological units in a cross-section through the northeastern end of the Jacques Lake deposit. For the surface location of the section refer to Figure 4.*

from drillcore indicate that the development of uranium mineralization is not always proportional to the intensity of the penetrative fabric, within the host volcanic succession. The region surrounding the Jacques Lake deposit is associated with a pronounced radiometric anomaly. Drilling carried out by Aurora-Energy has shown that the *in-situ* mineralization occurs at the southwestern end of this radiometric anomaly, with the northeastern trend of the anomaly likely due to glacial dispersion (Cunningham-Dunlop and Giroux, 2007; Figure 4). The most significant drillhole intersections recorded occur to the southwest of the airborne radiometric anomaly and have little to no surface expression. Extensive drilling carried out since 2005 has now defined the mineralization over a strike length of approximately 650 m and to a vertical depth of approximately 300 m (Figure 5). From this drilling it has been inferred that the uranium mineralization is also affected by the isoclinal folding that is developed within the host rocks (Bailey, 1979; Cunningham-Dunlop and Lee, 2008). As indicated above, this folding is related to regional F_2 folding and is interpreted to be synchronous with the formation of the penetrative D_2 fabric (Hinchey, 2007; Hinchey and Laflamme, *this volume*)

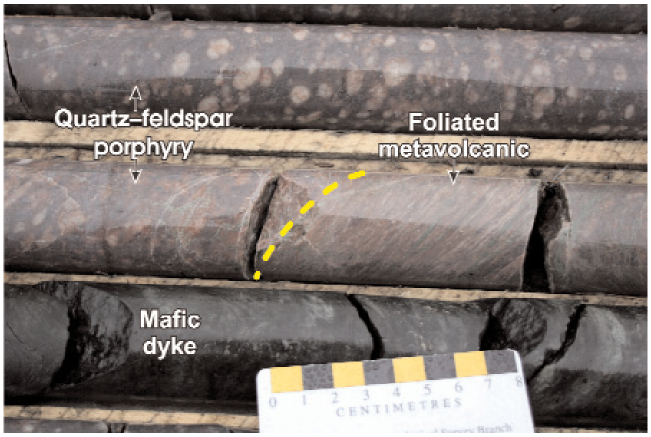

Plate 4. *Coarsely porphyritic quartz–feldspar-porphyry dyke intruding the strongly deformed ash-flow tuff. Note the lack of a fabric within the porphyry dyke, suggesting it post-dates development of the penetrative fabric.*

Uranium mineralization at the Jacques Lake deposit is spatially associated with the development of actinolite–magnetite–carbonate ± biotite ± pyrite veining (Cunningham-Dunlop and Valenta, 2006), which is accompanied by the development of hematite alteration and sodium metasomatism. Uranium grades within the deposit generally range from 0.03 to 0.66 % U_3O_8 with localized higher grade intersections. Mineralization is locally accompanied by up to 9.5 w.t. % Na_2O in association with the sodium metasomatism related to the mineralization. Regions of significant mineralization are associated with intense veining, which is accompanied by pervasive hematization of the adjacent wall rock. Several styles of veining are identified on the basis of mineralogy and their relationships to the penetrative fabric. The development of 'early' hornblende–epidote ± pyrite-rich veins is evident, as these veins are locally folded and rotated parallel to the penetrative fabric, or boudinaged parallel to the fabric (Plate 5a). These veins are generally barren and are interpreted to represent an early F_1 folding-event that is subsequently affected by D_2 deformation. These veins lack significant associated hematite alteration but are associated with minor 'bleaching' of the adjacent wall rock.

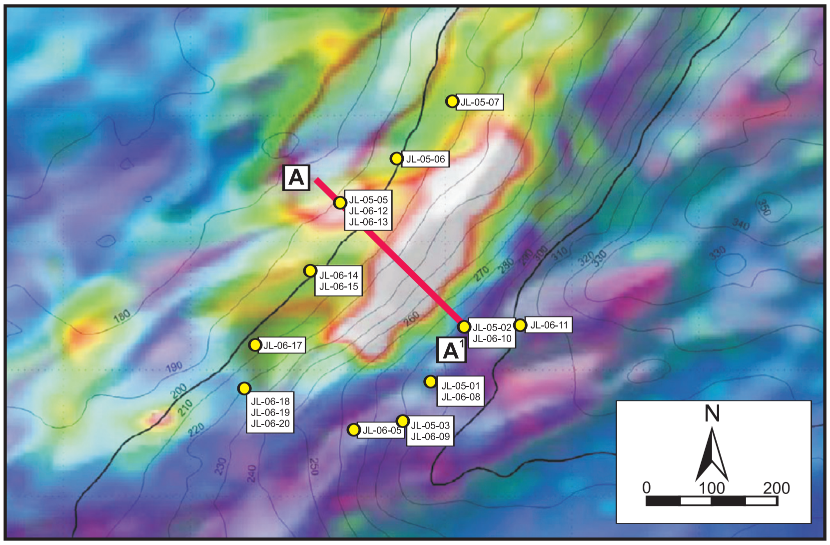

Figure 4. *Map showing northeastern trend of the Jacques Lake radiometric anomaly along with the location of the cross-section shown in Figure 3 (modified from Cunningham-Dunlop and Valenta, 2006).*

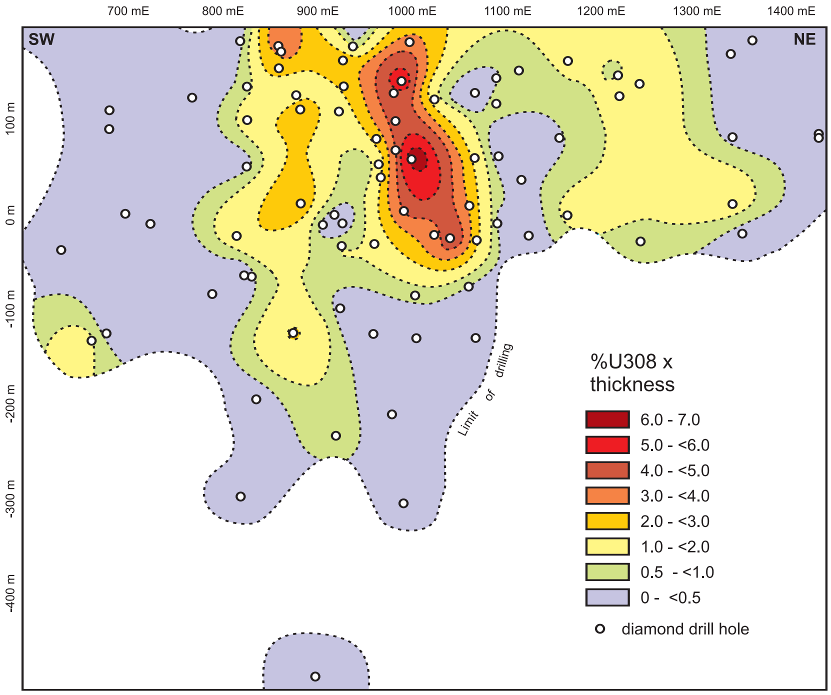

Figure 5. *Longitudinal cross-section of the Jacques Lake deposit displaying the current limit of drilling; taken from the Aurora-Energy Resources website.*

Uranium mineralization within the Jacques Lake deposit is predominantly associated with the development of wispy, discontinuous actinolite–magnetite–carbonate ± biotite ± pyrite fractures or veins. It is inferred that these veins represent a pre- to syn-deformational veining event related to D_2, as indicated by their parallelism with the main penetrative fabric. The hematite alteration associated with this style of veining is not everywhere developed but where present, locally coalesces to form regions of pervasive hematization resulting in a pale pink colouration within the host volcanic rocks (Plate 6a).

A third style of veining displays a more random, network-like geometry, and is inferred to postdate the penetrative fabric related to D_2. These veins have actinolite–biotite–hornblende-rich margins with a more carbonate-rich core and are generally barren with respect to uranium. A few such veins associated with anomalous radioactivity are interpreted to represent the local remobilization of uranium from previously formed mineralization (Plate 7).

SPECTRAL ANALYSIS OF VEINS

To better understand the similarities and differences between barren and mineralized veins, examples were examined using a TerraSpec® optical spectrometer (Thompson *et al.*, 1999). This instrument uses the reflectance spectra from the visible and infrared wavelengths to identify and quantify alteration assemblages. Specific minerals have unique reflectance spectra. In addition, several of the veins were examined in thin section to confirm the minerals identified through optical spectrometry. The pre-D_2 veining predominantly consists of fine-grained pale to dark green minerals, with little to no associated carbonate (Plate 5a). Spectra collected from this style of veining indicate that the veins are dominated by hornblende and lesser amounts of epidote (Figure 6). This was confirmed through thin-section analysis, in which the veining is seen to consist almost entirely of hornblende with only minor epidote and trace amounts of opaque minerals (Plates 5b and 5c).

The veining that is associated with the main uranium mineralization, has a somewhat different mineralogy. This style of veining is generally narrower and discontinuous, and it is, therefore, harder to acquire accurate spectra. In hand sample, the veins are generally magnetic and are dominated by fine-grained dark green mafic minerals in association with minor amounts of

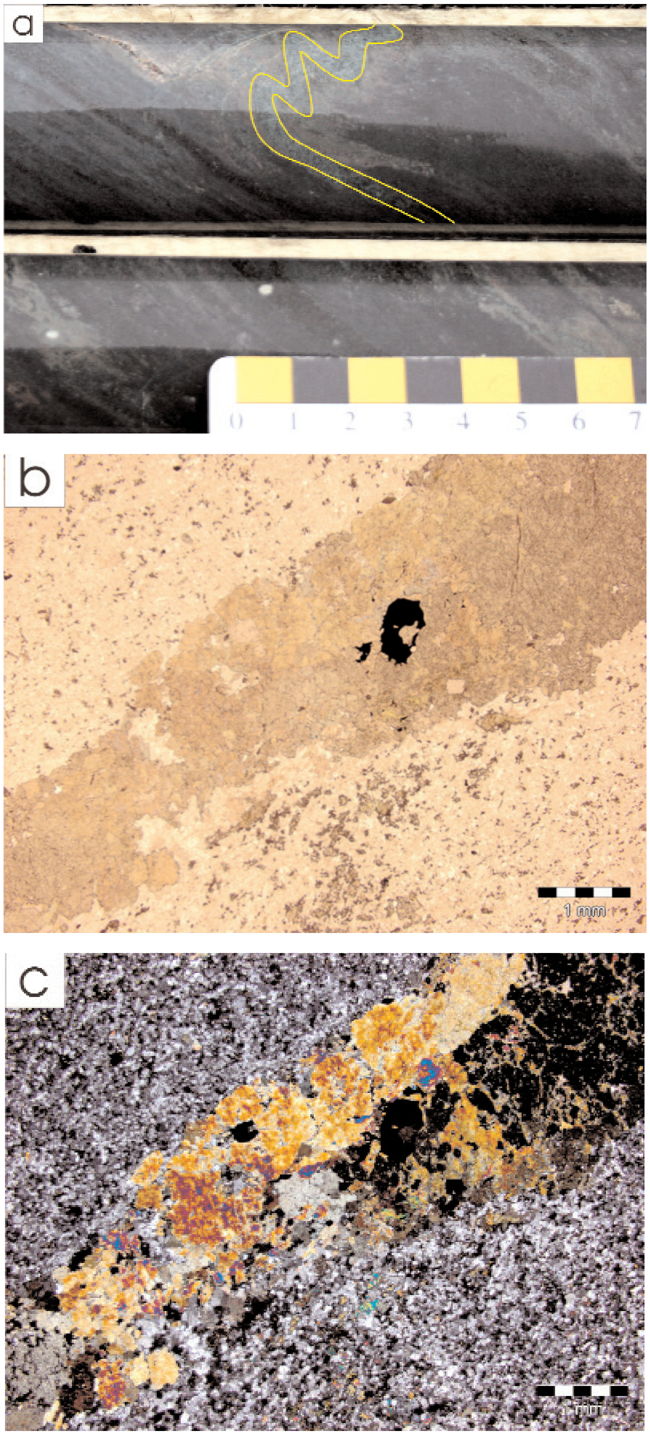

Plate 5. *a) Deformed, hornblende-rich veining, displaying isoclinal folding, and rotation parallel to the penetrative fabric, suggesting it is either an earlier* D_1 *event or formed synchronous with the final stages of* D_2*; and photomicrographs of the hornblende-rich vein containing trace amounts of epidote and minor opaque minerals, in b) plane-polarized light and c) in cross-polarized light.*

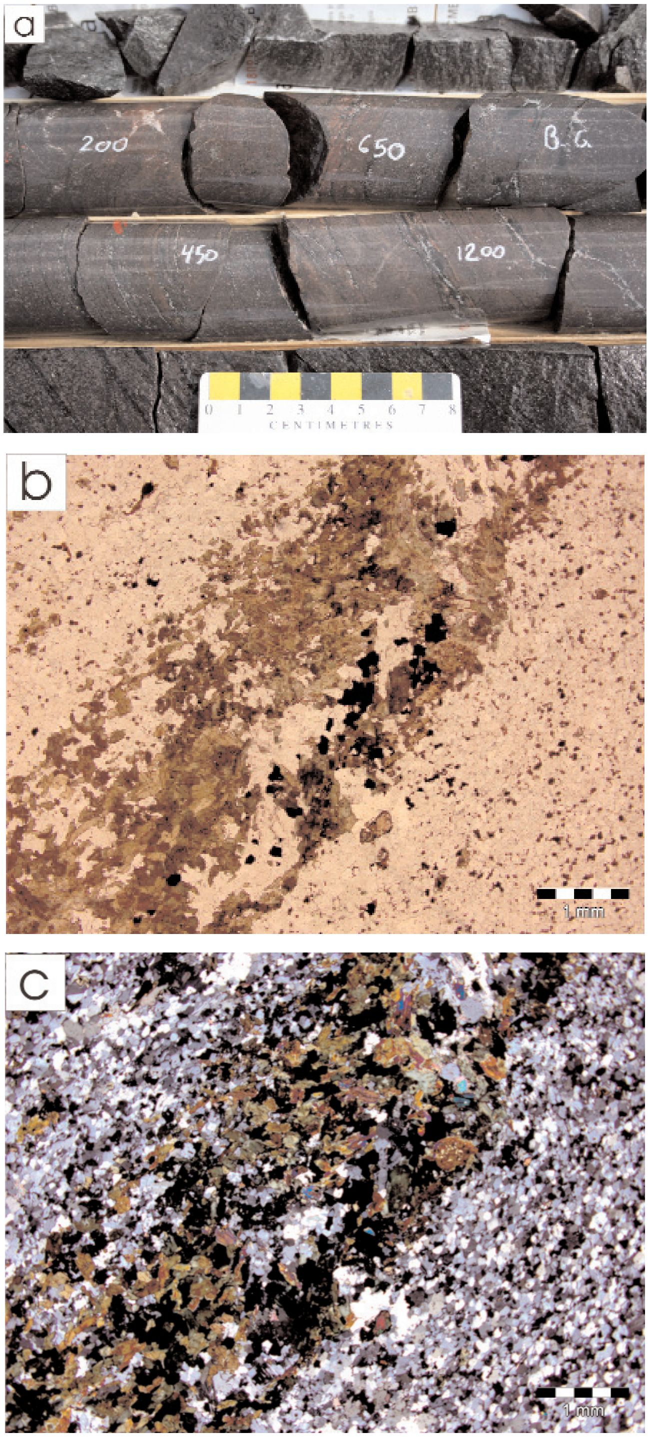

Plate 6. *a) Mineralized ash-flow tuff intruded by actinolite-rich veins and associated hematite alteration; and, photomicrographs of the mineralized actinolite-rich veins in b) plane-polarized light and c) in cross-polarized light; note the abundance of magnetite and carbonate near the core of the vein and the irregularly developed, actinolite-rich margin.*

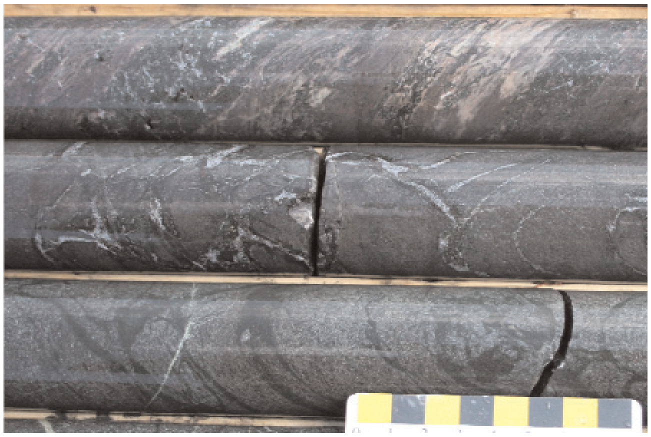

Plate 7. *Post-D_2 network-style, actinolite–biotite–chlorite veining; note the greater abundance of carbonate.*

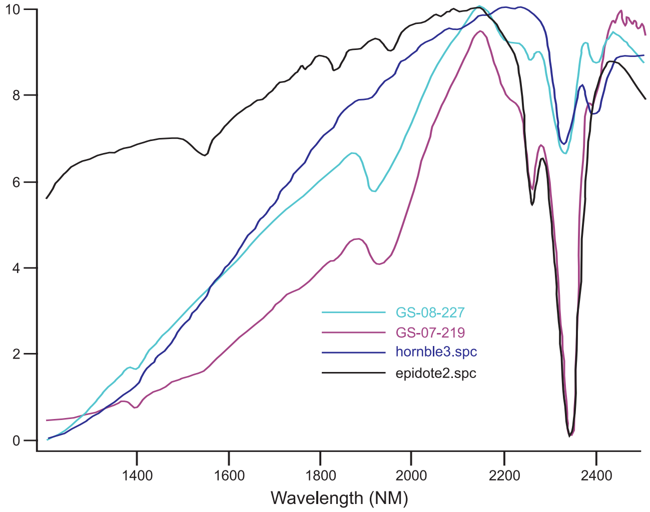

Figure 6. *Spectra from two examples of folded veins (GS-08-227 and GS-07-219) along with reference spectra for hornblende (hornble3.spc) and epidote (epidote2.spc).*

carbonate and magnetite. Spectra collected from these veins are dominated by actinolite and lesser carbonate (potentially siderite based on its spectra; Plates 6b and 6c; Figure 7). In thin section, the veins show moderate amounts of magnetite in association with carbonate in the centre of the veins, with actinolite and minor hornblende forming along the vein margins.

The network-style veining, inferred to be post-D_2, is associated with a greater abundance of carbonate and a notable absence of magnetite with respect to the other veins. Spectra collected from this style of veining suggest a mixture of hornblende and actinolite along with biotite and carbonate, however petrographic confirmation of this assemblage has yet to be carried out (Plate 7; Figure 8).

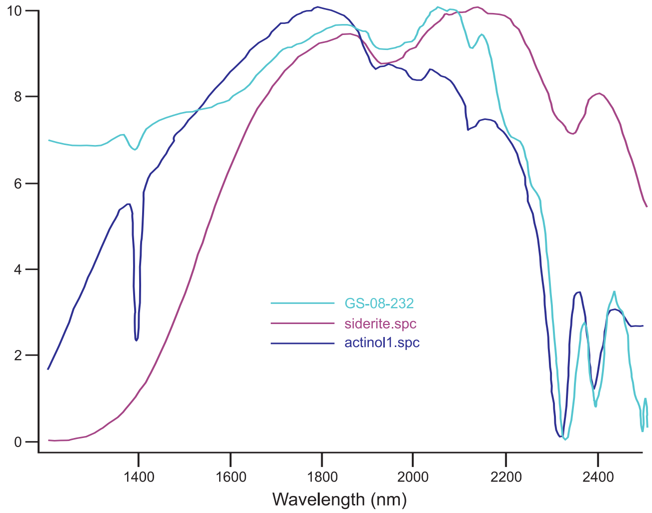

Figure 7. *Spectra from veining within a mineralized sample containing 0.15% U_3O_8 (GS-08-232) along with representative spectra for actinolite (actinol1.spc) and siderite (siderite.spc).*

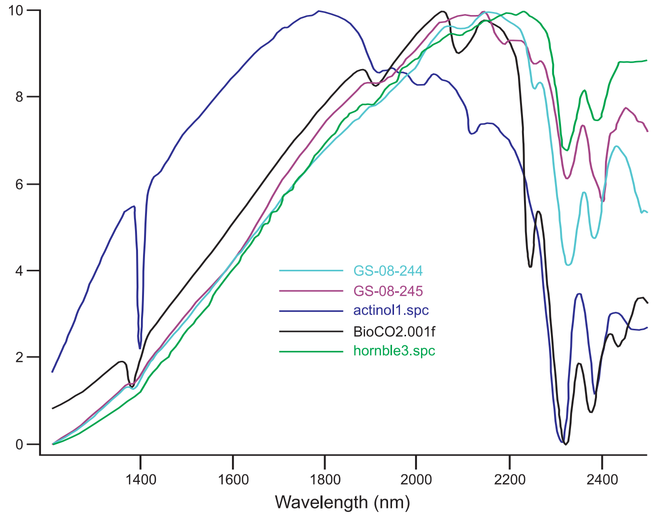

Figure 8. *Spectra from two examples of post-D_2 veining (GS-08-244 and GS-08-245) along with reference spectra for actinolite (actinol1.spc), biotite (BioCO2.001f) and hornblende (hornble3.spc).*

Although the spectra from the 'early' veining (Figure 6) and the veining associated with mineralization (Figure 7) are distinct, resolution of the narrow vein sets and the mixtures of the different minerals within the veins locally produce complex spectra that are difficult to interpret. Preliminary results do indicate that there are distinct differences between the various styles of veining, however further spectrographic analysis coupled with petrographic analyses are required to better understand the intimate mineral assemblages and their relation to mineralization and deformation.

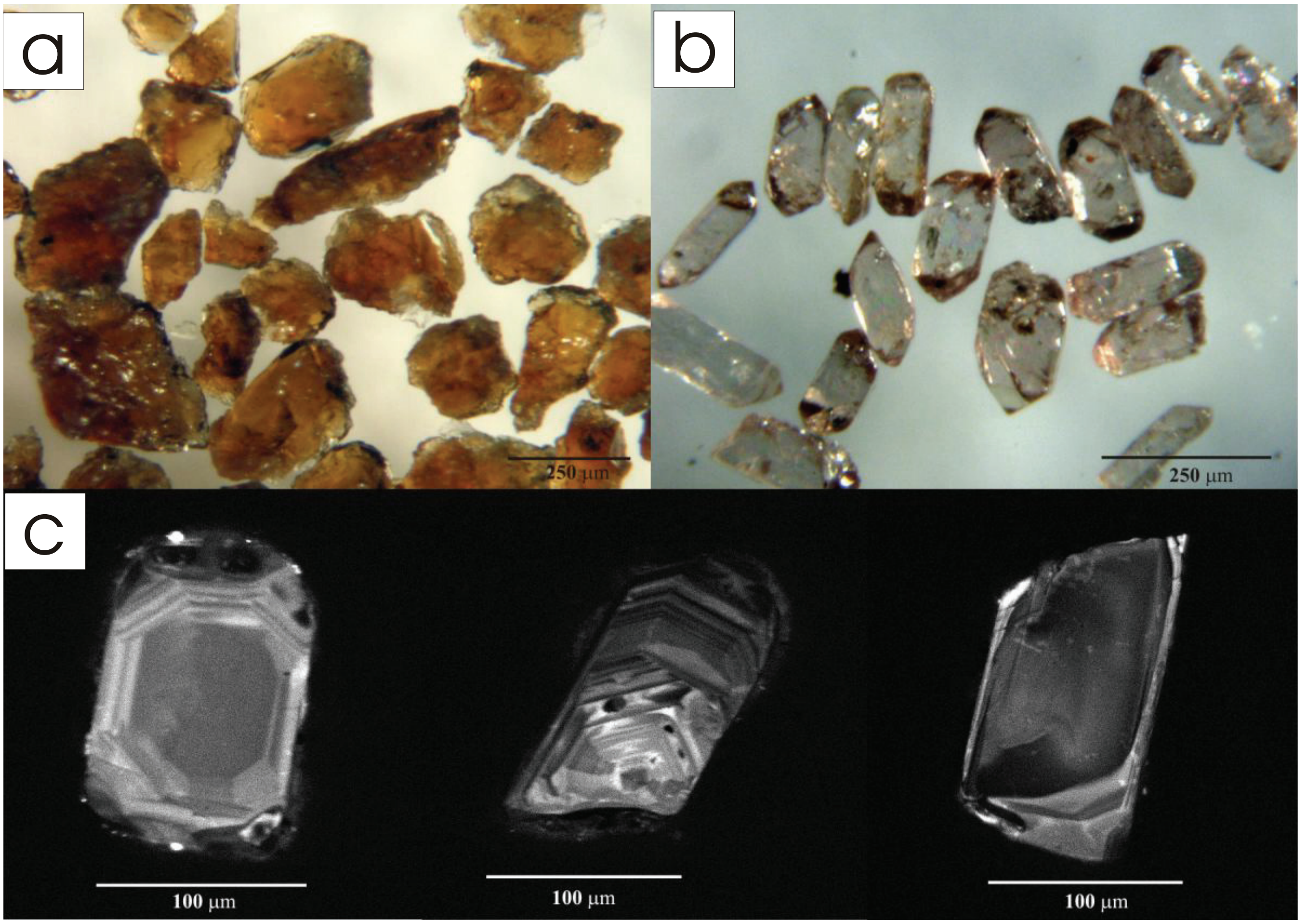

Plate 8. *a and b) Titanite and zircon separates from the Jacques Lake quartz–feldspar-porphyry dyke, respectively; c) cathode luminescence images displaying irregularly developed fine-scale igneous growth zoning in zircon crystals.*

GEOCHRONOLOGICAL CONSTRAINTS

The relationships between vein development and the penetrative fabric within the host metavolcanic rocks suggest that the uranium mineralization is pre- to syn-D_2. The mineralization is locally crosscut by a distinctive quartz–feldspar-porphyry dyke (*see* page 85), which is an obvious target for geochronological studies aimed at determining a minimum age for the mineralization. A sample of the porphyry dyke was collected from drillhole JL-06-10, between 362.0 and 372.0 m (Figure 3). The heavy mineral separate from this quartz–feldspar-porphyry dyke yielded a large amount of zircon and titanite as well as molybdenite and fluorite. The zircon occurs as equant euhedral prisms, that display fine-scale igneous growth zones in cathode luminescence images and some of these contain mineral and melt inclusions (Plate 8). The titanite form coarse subhedral to anhedral grains (Plate 8a) and are observed in thin section in an apparent igneous intergrowth.

Analytical techniques used are described in Sánchez-Garcia *et al.* (2008) and the results are reported in Table 1 and presented in Figure 9. Six analyses of zircon with fractions of 1 to 9 grains are concordant to 3% discordant on the accompanying concordia diagram (Figure 9) and their $^{207}Pb/^{206}Pb$ dates vary from 1807 ± 8 to 1798 ± 6 Ma. Three analyses of titanite, with fractions of 1 or 2 grains, are concordant and overlap on a concordia diagram. The six zircon analyses yield an age of 1801 ± 1.1 Ma, whereas the three titanite analyses on their own yield an age of 1801 ± 2 Ma. A weighted average of the $^{207}Pb/^{206}Pb$ dates of all nine analyses yields a date of 1801 ± 0.9 Ma (95% confidence interval, MSWD= 0.85. prob. of fit= 0.56) for the crystallization age of this rock. The age provides a minimum age limit on the development of the D_2 fabric and uranium mineralization within the Jacques Lake deposit. Ongoing geochronological work, as part of this study, continues to try and further constrain the age of the mineralization through the dating of the footwall granite as well as the host rocks to the mineralization.

Table 1. U–Pb data for the Jacques Lake quartz–feldspar-porphyry

		Concentration		Measured		Corrected Atomic Ratios*						Age (Ma)		
Fraction	Weight (mg)	U ppm	Pb rad ppm	total common Pb (pg)	$^{206}Pb/^{204}Pb$	$^{208}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
Z1 1 lrg equ euh abr	0.004	213	72.2	19	954	0.1048	0.32408	162	4.9118	276	0.10992	36	1810	1804	1798
Z2 2 lrg euh equ abr	0.008	145	48.2	7.7	3051	0.0972	0.32008	252	4.8709	332	0.11037	46	1790	1797	1805
Z3 2 lrg equ euh abr	0.008	99	33.4	2.7	5946	0.1139	0.32058	214	4.8819	264	0.11045	46	1793	1799	1807
Z4 7 lrg euh abr	0.021	179	59.9	22	3457	0.1160	0.31774	86	4.8242	130	0.11012	12	1779	1789	1801
Z5 9 lrg euh abr	0.027	129	42.2	1.7	40870	0.1064	0.31240	98	4.7405	142	0.11005	16	1753	1774	1800
Z6 7 lrg euh abr	0.021	127	42.3	3.5	15347	0.1039	0.31828	150	4.8356	202	0.11019	28	1781	1791	1803
T1 1 lrg brn abr	0.005	729	264.8	37	2008	0.1994	0.32228	122	4.8921	186	0.11009	14	1801	1801	1801
T2 2 sml clr dk brn abr	0.006	317	113.8	30	1306	0.1870	0.32155	142	4.8812	190	0.11010	28	1797	1799	1801
T3 2 sml clr brn abr	0.006	259	94.2	24	1300	0.2054	0.32163	112	4.8793	152	0.11003	24	1798	1799	1800

Notes:
Z=zircon, T=titanite, lrg=large, sml=small, equ=equant, euh=euhedral, brn=brown, all fractions were strongly abraded (Krogh 1982). pg=picogram.
* Atomic ratios corrected for spike, lab blank of 1-2 picograms, isotopic fractionation. Common lead above the lab blank was subtracted according to the model of Stacey and Kramers (1975) for the age of the sample. Two sigma uncertainties are reported after the isotopic ratios and refer to the final digits.

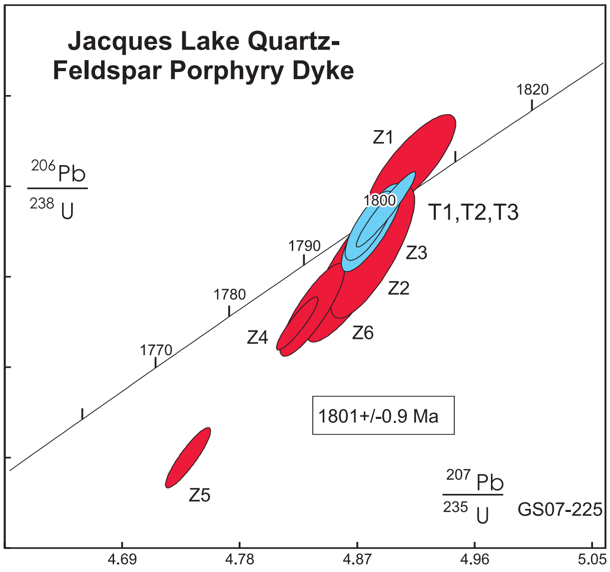

Figure 9. *Concordia diagram of zircon and titanite U–Pb results from sample GS-07-225, a quartz–feldspar-porphyry dyke. Error ellipses are at the 2σ level. Zircon data is coloured red and titanite data is coloured blue.*

The 1801 ± 0.9 Ma age is broadly consistent with the results of Schärer *et al.* (1988) for the porphyry dyke at White Bear Mountain and is similar to other ages of intrusive rocks elsewhere in the Makkovik Province (Kerr *et al.*, 1992). If the host rock at Jacques Lake is correlatable in age with those at Michelin Ridge (1856 ± 2 Ma; Schärer *et al.*, 1988), the uranium mineralization can be constrained between ca. 1856 and 1801 Ma.

SUMMARY AND CONCLUSIONS

The Jacques Lake uranium deposit occurs on the northern end of a regional mineralized trend, which has a strike length of some 30 km, and hosts several significant uranium occurrences including the well-known Michelin deposit. Mineralization at Jacques Lake is hosted within variably deformed intermediate ash-flow tuffs that are affected by hematite alteration and sodium-metasomatism in association with the development of uranium mineralization. The style of mineralization resembles that at the Michelin deposit in terms of the associated alteration and the nature of the host rocks, but there are differences between the two deposits. Mineralization within the Michelin deposit is disseminated throughout the mineralized zone, whereas at Jacques Lake, mineralization is more restricted to vein development. These veins appear to have pre- to syn-deformational timing relative the penetrative fabric related to D_2. The volcanic host rocks at the Jacques Lake deposit do not display the characteristic pale cream colour associated with intense sodium-metasomatism as seen at the Michelin deposit, even though preliminary geochemistry indicates that similar sodium values occur within mineralized samples at each deposit. At the Jacques Lake deposit, uranium mineralization is associated with actinolite, magnetite and carbonate. In contrast at the Michelin deposit, mineralization is reportedly associated with sphene, aegirine–augite, andradite and ilmeno-magnetite (Evans, 1980).

The style of mineralization at both Jacques Lake and Michelin was broadly grouped under the 'metamorphic-metasomatic' classification by Sparkes and Kerr (2008). This is supported by the strong spatial association between the formation of uranium mineralization and associated sodium-metasomatism within zones of intense deformation. However, it is still unclear whether the deformation occurs within these regions because of the pre-existing alteration or if the alteration exploits regionally developed shear zones that later become reactivated. The minimum age for both the mineralization and the deformation within the Jacques Lake deposit is now defined at 1801 ± 0.9 Ma, and if the age of 1856 ± 2 Ma from Michelin Ridge is correlated, then uranium deposition must have occurred between 1856 and 1801 Ma. Ongoing geochronological studies will ideally provide better constraints for the age of mineralization at the Jacques Lake deposit by providing an age for the metavolcanic host rocks and the footwall intrusion.

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