Iron Oxide-Copper-Gold ±Uranium in the Great Bear Magmatic Zone: Nature of Uranium in IOCG Systems

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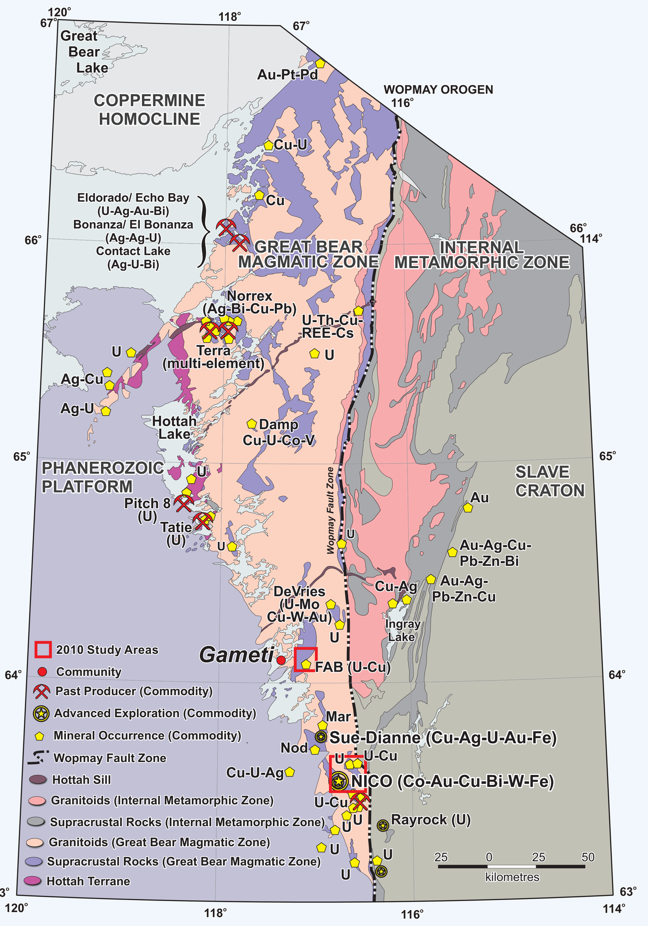

Figure 1 (left): Simplified geological map of the Great Bear magmatic zone (GBmz) illustrating known mineral showings, prospects and past-producing mines (cf. Corriveau et al., 2010a). 2010 study areas are highlighted in red (NICO and Gameti-Fab Lake areas).

Introduction

Under the Northern Uranium for Canada project and the IOCG/ Multiple Metals Great Bear Region project of the Geomapping for Energy and Minerals (GEM) program, the nature of uranium in iron oxide-copper-gold (IOCG) systems is being investigated using examples from the southern Great Bear magmatic zone (GBmz). Hypotheses being addressed include: Can uranium and thorium serve as vectors to multiple-metal endowments in IOCG systems? What is the potential for GBMZ IOCG systems to contain recoverable energy resources? How can we maximize geological vectoring to ore with the geochemical information retrieved in the field by observing the mineral parageneses of alteration haloes and analyzing K, eU and eTh with portable gamma-ray spectrometers?

During the summer of 2010, fieldwork focussed on known IOCG alteration systems of the Southern GBmz with anomalous uranium and thorium showings at Lou, Cole and Fab Lakes. During the regional IOCG alteration mapping, several new thorium and uranium occurrences were discovered in the Fab and Lou Lake areas.

Thorium (Th) and uranium (U) concentrations presented in this poster were determined by portable gamma-ray spectrometer measurements taken in the field (denoted as eU and eTh). At the time of publication, the majority of these anomalies have been verified by laboratory geochemical analyses.

Lou Lake U-occurrences

At Lou Lake, two new U-Th-bearing breccias were discovered on the NICO property and a large U+Th-enriched granitic dyke was sampled west of the property (Fig. 2).

The first discovery is a localized (~1.5 m wide, 3 m long) U-bearing breccia lense located structurally above of the NICO deposit. The polymict breccia contains altered felsic porphyry and metasedimentary clasts set in an amphibole-magnetite matrix (Figs. 3 & 4). The breccia occupies the contact between intensely altered biotite-amphibole-magnetite (BAM) metasedimentary rocks of the Treasure Lake Group in the vicinity of an altered felsic feldspar porphyry and is elongated in the direction of the dominant host rock foliation (124°/82°). *In situ* concentrations as high as 525 ppm eU are associated with late, <1 cm wide hematite-quartz veinlets concentrated within the breccia and which cross-cut the dominant foliation. This ~120° trend parallels the larger, breccia corridor to the south, discovered by GSC staff in late 2010. This southern U anomaly comprises a 3 km long, U-Th-arsenopyrite breccia corridor (eU = 0.01-1%, eTh ≤0.2%; *cf.* Montreuil et al., 2010; Corriveau et al., 2011). Anomalous U appears associated with hematized magnetite veins, potassium-rich magnetite alteration and earthy hematite veins, all within bright red silicified and albitized zones developed in the host metasedimentary rocks.

To the east of the NICO deposit, a large (10-15 m wide) granitic dyke intrudes intensely sheared Treasure Lake Group metasediments (Figs. 5 & 6) and outcrops along strike for approximately 60 metres. The massive dyke contains disseminated U and Th-mineralization, with concentrations up to 178 ppm eU and 115 ppm eTh detected. Although the dyke is cross-cut by late quartz-tourmaline veinlets, the U and Th-enrichment appears primary and as such, represents a U-Th enriched source post-dating deformation of the Treasure Lake Group metasediments. Further mineralogical and geochronological studies are underway.

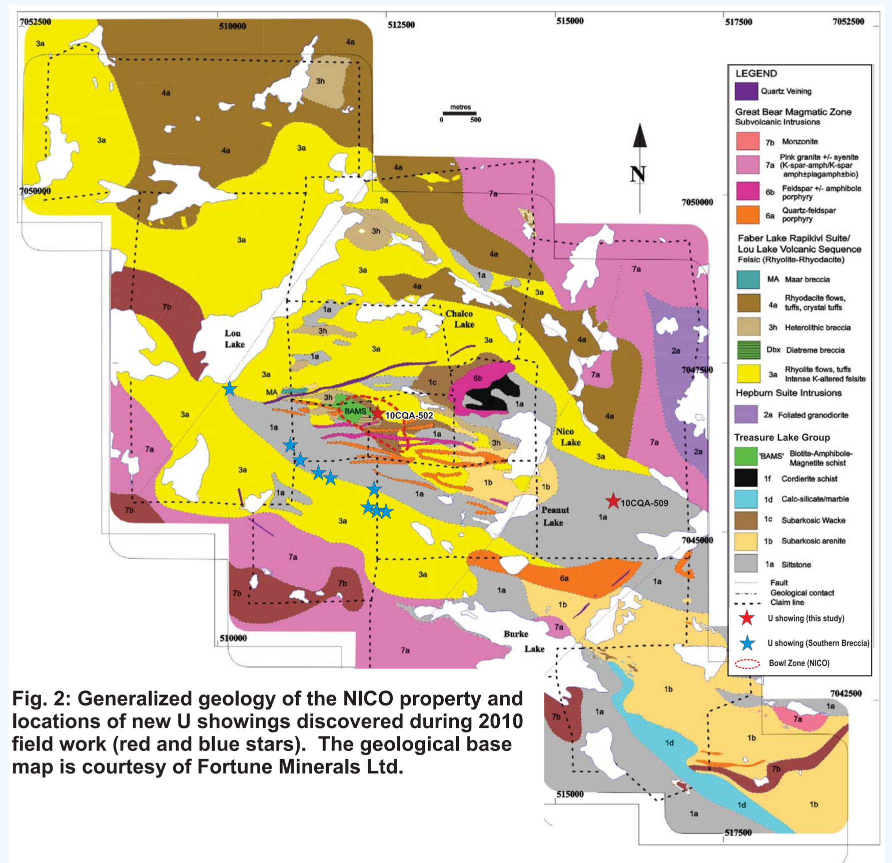

Fig. 2: Generalized geology of the NICO property and locations of new U showings discovered during 2010 field work (red and blue stars). The geological base map is courtesy of Fortune Minerals Ltd.

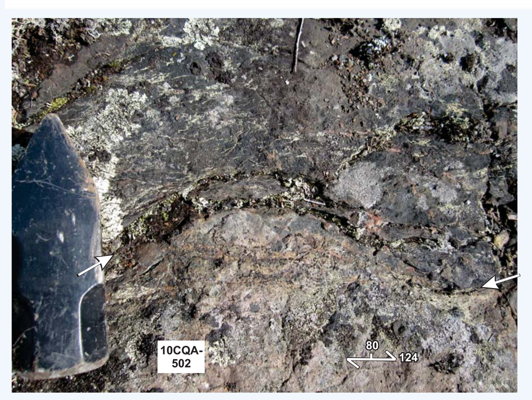

Fig. 3: White arrows indicate location of the sharp, irregular contact between the heterolithic non regionally metamorphosed amphibole-magnetite rich breccia (top) and foliated Treasure Lake Group metamorphosed sandstone (bottom). The U-bearing quartz-hematite veinlets are preferentially hosted in the breccia and strike obliquely to the dominant 124/80° foliation. Station 10CQA-502

Fig. 4: Polished slab of the localized heterolithic breccia, containing intensely altered feldspar porphyry clasts set in an amphibole-magnetite cement. Pyrite and arsenopyrite grains (circled) are disseminated throughout and in K-feldpar+quartz veinlets.

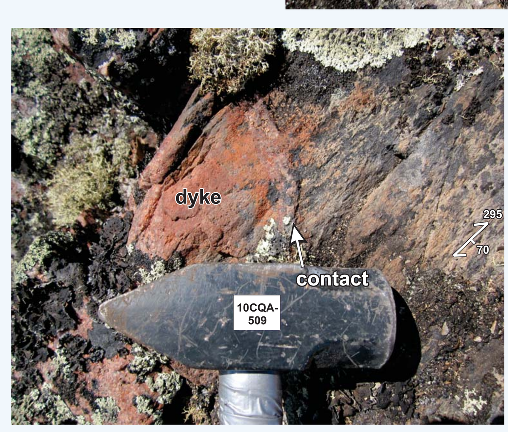

Fig. 5: Sharp intrusive contact of the fertile granitic dyke. Shear-sense indicators within intensely 295/70° foliated Treasure Lake Group metasediments indicate a predominantly dextral movement. Station 10CQA-509.

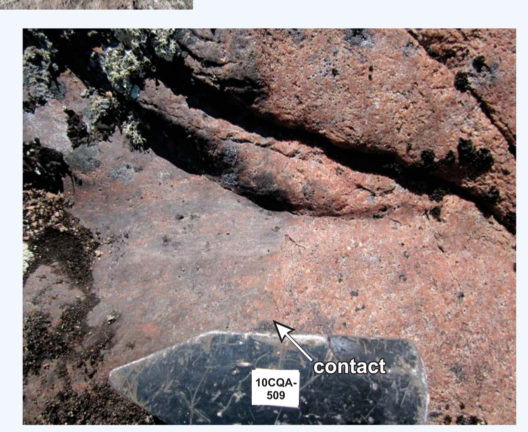

Fig. 6: Intrusive contact of massive, U- Th-enriched granitic dyke (right) intruding deformed Treasure Lake Group metasiltstone. Station 10CQA-509.

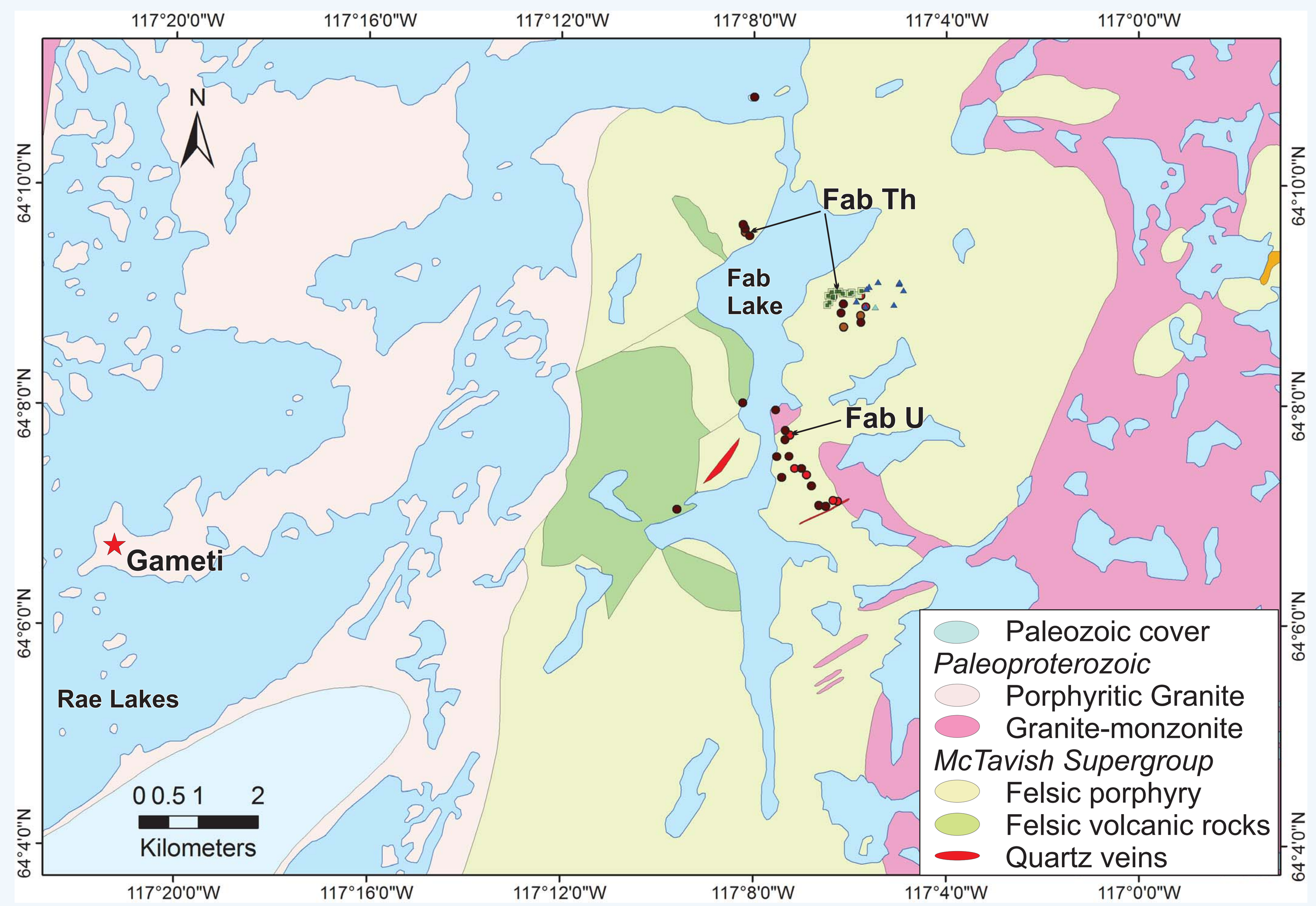

Fig. 7: Geological map of the Fab Lake region, highlighting the 2010 mapping stations (circles, squares and triangles) and the new Th- and U-showings. Geology from Jackson (2008).

FAB Lake U-occurrences

A new U occurrence was found during regional mapping on the eastern shoreline of Fab Lake within magnetite-rich replacement fronts (Figs.13 &14) developed in medium-grained, feldspar porphyry of the McTavish Supergroup. These alteration fronts are overprinted by K-feldspar+magnetite veins containing trace pyrite±chalcopyrite and cut by another generation of amphibole±magnetite veinlets.

The new occurrence comprises several east-west trending <20 cm wide swarms of magnetite veinlets and replacement fronts containing up to 3595 ppm eU developed within brittle deformation zones. The intensity of magnetite alteration ranges from veinlets to near-complete replacement of the host feldspar porphyry. The highest U concentrations also appear to correlate with the intensity of late, bright red K-feldspar±magnetite veins and breccia matrices (Fig. 16).

Preliminary field observations indicate that the nature of the U mineralization is similar to that of the historical FAB showings, being associated with intense magnetite replacement (Gandhi, 1988). Although Gandhi (1988) proposed that U deposition was macroscopically contemporaneous with magnetite precipitation, the presence of hematite and some textures suggest that U mineralization may post date magnetite precipitation and that the U deposition involved circulation of late, oxidized, U-bearing fluids which encountered Fe^{2+} rich magnetite (U precipitation triggered by redox reactions). The historic FAB showings were also sampled during the study to examine the nature of the U enrichment using modern analytical techniques and to investigate the apparent contrast in U-Th concentrations with the FAB Th-rich occurrences.

Fig. 13: Intense amphibole-magnetite replacement front (dark grey) cross-cut by K-feldspar + magnetite veinlets within medium-grained feldspar porphyry (pink) of the McTavish Supergroup. Box outlines the area of Fig. 14. Station 10CQA-562.

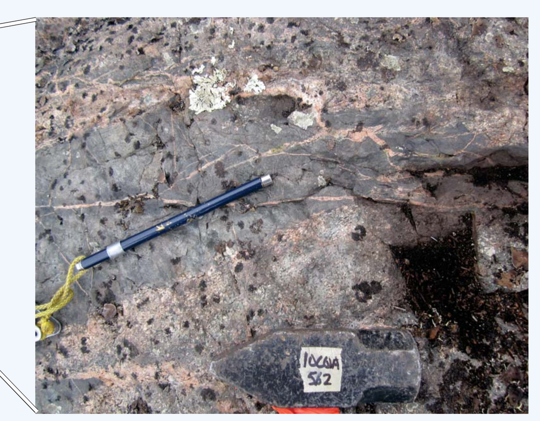

Fig. 14: Leading edge of the magnetite-amphibole replacement front illustrated in Figure 13, cross-cut by anastomosing K-feldspar+magnetite veinlets. Station 10CQA-562

Fig 15: Pyrite-bearing, potassium feldspar veinlets cross-cutting the main phase of amphibole-magnetite alteration. Sample 10CQA-562

Fig. 16: Pocket of intense, K-feldspar±magnetite veins and breccia. Preliminary observations indicate that the intensity of the veining correlates with increasing U concentrations.

FAB Lake Th-Occurrences

Several new Th anomalies were discovered on the eastern and northwestern shorelines of Fab Lake within numerous amphibole-magnetite veins and breccias hosted within McTavish Supergroup felsic feldspar porphyry (Figs. 8-10). The older medium-grained porphyry is sharply cross-cut by relatively unaltered, coarser grained, two-feldspar porphyry dykes trending 045°/80° (Figs. 8 & 12). These units were sampled for geochronology to constrain evolution of the hydrothermal system.

The medium-grained feldspar porphyry exhibits varying degrees and multiple generations of sodic (albite), potassic-iron (K-feldspar, biotite, magnetite and hematite) and calcic-iron (amphibole, magnetite) alteration (Fig. 10). Although the late two-feldspar porphyry contains biotite, this is interpreted to be primary based on textures and lack of concomitant iron-oxide alteration. More importantly, the younger two-feldspar porphyry dykes lack amphibole-magnetite alteration, which is the dominant alteration assemblage at Fab Lake.

At the northwest occurrences, amphibole-magnetite veins up to 2 m wide trend 165°/84° and contain up to 144 ppm eTh with only moderate U contents (23 ppm eU, Th/U = ~4-10, Table 1, Fig. 11). These vein systems record decoupling of U and Th, either through movement of typically immobile Th following U deposition, or enrichment of Th+U followed by U removal. Figure 11 illustrates Th/U relationships of the enriched zones with comparison to average upper crustal Th/U ratios (3.5 - 4.0; Cuney, 2009). Hydrothermal U occurrences typically exhibit lower Th/U values, as a result of the immobility of Th^{4+} versus highly mobile U^{6+}. One occurrence discovered in 2010 does contain anomalously high U relative to Th, suggesting that U was leached from similar vein systems during a late alteration event.

Fig. 8: Two generations of felsic feldspar porphyry dykes. The older, medium-grained feldspar porphyry (top) has amphibole-magnetite alteration, as highlighted by its greater magnetic susceptibility. Station 10CQA-185.

Fig. 9: Th-bearing, amphibole+magnetite cemented breccia containing potassic-altered, feldspar porphyry clasts. Station 10CQA-552.

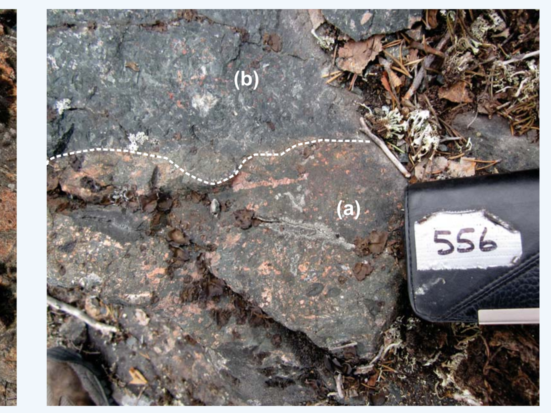

Fig. 10: Two generations (a & b) of amphibole-magnetite veins, the youngest (b) of which appears to be more Th-enriched and contains fewer porphyry clasts. Station 10CQA-556

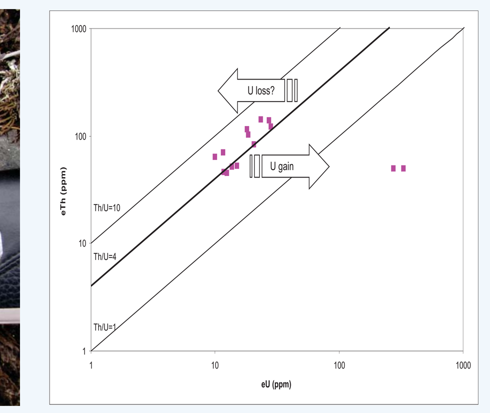

Fig. 11:eTh/eU ratios of the Th-bearing veins and breccias, plotted with reference to the average crustal Th/U ratio (~4) (Cuney, 2009). Hydrothermal transport is typically expressed by lower Th/U values.

Fig. 12: Amphibole-magnetite breccia sharply cross-cut by coarse-grained, felsic two-feldspar porphyry. Station 10CQA-559.

Table 1: eU and eTh values of the Fab Th-U-showings

Station ID	eU (ppm)	eTh (ppm)	Th/U
10CQA-0185	28	123	4.4
10CQA-0185	21	84	4.1
10CQA-0187	274	50	0.2
10CQA-0187	331	50	0.2
10CQA-0192	23	144	6.2
10CQA-0192	12	46	3.7
10CQA-0195	10	64	6.4
10CQA-0195	12	47	4.0
10CQA-0195	15	53	3.5
10CQA-0560	18	117	6.4
10CQA-0560	12	70	6.0
10CQA-0574	27	139	5.1
10CQA-0556	18	103	5.6
10CQA-0556	14	52	3.8

Preliminary Conclusions

As noted by Ootes et al. (2008), the country rocks surrounding most of the aforementioned U and Th showings contain elevated concentrations of U and Th. Field surveys using portable spectrometers during this study confirmed the previous observations and highlighted the presence of additional primary enrichments in U and Th (e.g. the Lou Lake granitic dyke). Additional studies on these units are investigating the extent and degree of pre-existing availability of U and Th in the country rocks, and the mobility of U and Th in the country rocks and mineralized zones during multi-phase IOCG alteration.

The previously documented U occurrences in the Fab Lake region share many mineralogical features with the Th- (±U) rich amphibole+magnetite veins and breccias noted during the 2010 field season. As noted by Gandhi (1988), U deposition in the FAB showings appears to have been contemporaneous with magnetite precipitation, yet the majority of Th-bearing veins and breccias are relatively depleted in U, recording decoupling of Th from U. This enrichment of Th relative to U is atypical for hydrothermal systems, given the relative immobility of Th^{4+} versus highly mobile U^{6+}. Given the inferred nature of the fluids responsible for vein and breccia formation, the fluid chemistry should have permitted transportation of both U and Th (as carbonate and/or fluoride complexes). This is especially relevant in the Great Bear magmatic zone, which is characterized by elevated U contents of the country rocks. Were these amphibole-magnetite systems originally U-bearing and did they record U leaching in response to a late alteration event? Or, did the decoupling take place during hydrothermal fluid evolution and, if so, can these enigmatic veins and breccias be used as vectors toward ore through monitoring of Th/U ratios? Alteration mapping vectors developed through extensive fieldwork by Corriveau et al. (Fig. 17) suggest the latter. In this case, further examination of the Fab U showings is warranted.

Finally, given the ability of these systems to transport typically "immobile" elements, do the altered rocks have potential to host economic concentrations of other immobile elements such as rare-earth elements (REE)?

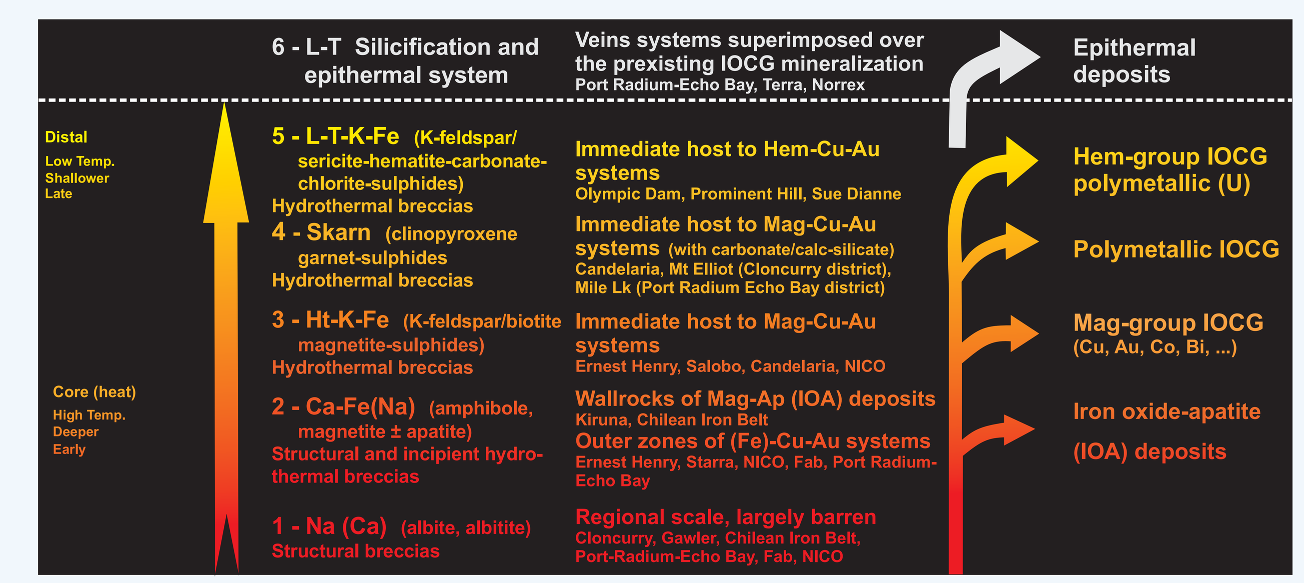

Fig.17: Alteration zoning vectors for the IOCG family of deposits. U mineralization is proposed to have developed in distal hematite-group systems (e.g. Olympic Dam). From Corriveau et al. (2010b).

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