Vein- and Shear Zone-Hosted Uranium Mineralization of the 46 Zone and Hab Mine Areas, Beaverlodge Uranium District, Northern Saskatchewan: Preliminary Petrology and Geochemical Results

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Summary

The Beaverlodge Uranium District has been the site of considerable exploration, exploitation, and scientific inquiry for many decades. The vast majority of economically important uranium deposits in the Beaverlodge District have been interpreted as epigenetic, with perhaps only the Bolger Pit uranium deposit being of surficial supergene origin and several primary alaskitic U enriched zones. Two past-producing mining properties within the Beaverlodge Uranium District were selected for detailed geological mapping during the summer 2009 field season; the former Hab mine and the '46 Zone'. The primary objectives of the this mapping was: 1) to characterize and determine the history of the lithological units that host (or are associated with) several selected uranium deposits in the Beaverlodge Uranium District, and 2) to develop an understanding of the genesis of the uranium-mineralized zones and ore bodies that lie therein. One of several key factors in the understanding of the genesis of uranium deposits is the identification and paragenesis of the associated alteration(s) of the host rock(s) and their relation to the uranium mineralizing fluids.

Introduction

The Beaverlodge Domain, which encompasses the Beaverlodge Uranium District, is a variably metamorphosed and deformed lithotectonic domain within the southwestern Rae Province in northern Saskatchewan (Fig. 1). Within the Beaverlodge Uranium District, uranium mineralization at the former Hab mine and 46 Zone examined during this study occurs in dominantly east-southeast-trending fractures and composite fracture/brecciated zones occurring within locales of variably high strain in both the ductile and brittle regimes. . This epigenetic style of uranium mineralized zones is similar to many of the other larger uranium deposits that occur within the Beaverlodge Domain (e.g., Ace-Fay-Verna). Highly evolved granite bodies (alaskitic

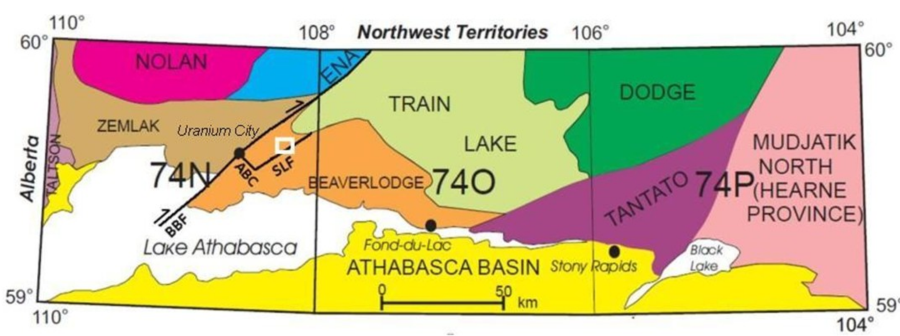

Figure 1: Location map showing the lithotectonic domains of the southern Rae Province in north-western Saskatchewan. The study area is outlined by white box. SLF-St. Louis Fault, ABC-ABC Fault, BBF-Black Bay Fault. The map is modified after Ashton et al. (2007b).

leucogranites) found within zones of variably high strain within the study area are also being examined to assess, if they could be the source of uranium. Abundant uranium may have been leached and mobilized from such granite bodies, such as the radioactive pink leucogranite and Donaldson Lake Granite, during widespread faulting and shearing; the actual fluid circulation mechanism is under investigation, although may involve high heat production basement rocks. This study's focus will be on highlighting the factors controlling the localization and saturation of uranium mineralization in both study areas, including the associated alteration types in the immediate host rocks. . During hydrothermal activity various paragenetic stages of mineralization and alteration were preserved; these include: sericitization and chloritization of albite and potassium feldspars; quartz-carbonate vein infill and contemporaneous quartz +/- carbonate vugs developed in locales where space was available, and uranium (mainly pitchblende) saturation resulted. Beck (1969) described the mineralized fractures at the Hab Mine as fractures within a shear filled with quartz accompanied by minor amounts of carbonate, hematite, chlorite, and pyrite with pitchblende. He further states pitchblende is disseminated in the vein material and wall rocks as small grains and vienlets. At the 46 zone, two uranium zones exist; with both being veins and fracture type along, or near, east-northeasterly trending faults and fractures just west and in the footwall of the major northeasterly trending St. Louis Fault. Thus, the setting is similar to the Hab, although quartz veining is less predominant and instead the 46 Zone comprises a more uranium-enriched fault breccia mineralization.

Geology

Archean basement granites were unconformably overlain by the Murmac Bay Group, a greenschist to amphibolite facies supracrustal succession containing quartzite, dolostone, psammite, iron formation, mafic rocks, prior to ca. 1.93 Ga amphibolite-facies metamorphism, which was accompanied by emplacement of widespread leucogranite and coeval development of an early east-southeast-trending D1-D2 structural fabric. This was followed by a second thermotectonic event at about 1.91-1.90 Ga at which time the early fabric was largely transposed by northeast-trending D3 folding and complex shearing and faulting accompanying differential exhumation. This was followed by unconformable deposition of the Martin Group fluvatile redbeds, and the D4 deformational event, which resulted in open north-trending folds and a network of faults comprising a northeast-trending dextral set (e.g., Black Bay Fault) and subordinate east-trending normal and southeast-trending sinistral sets, consistent with an east-west shortening regime (Ashton et al., 2009). The brittle nature of the D4 deformational event played a key role in the genesis of conduits along which the primary uraniferous fluids were transported and deposited about 1.78 Ga (Koeppel, 1968). The 46 Zone uranium deposit(s) is located in the footwall of the St. Louis Fault, a major east-northeasterly striking structure that dips ~50 degrees towards the southeast. Shear and faulting related to the activation and reactivation of faulting along the St Louis Fault. This is evident sub-parallel secondary structures in the area as well as within the various fault and sheared rocks of the region. The main rock types at the 46 Zone include amphibolite, quartzite, and metasedimentary mica schist of the Murmac Bay Group, intrusive pink leucogranite, and various cataclastic and tectonic schists derived by the intense deformation of these units. The Hab Mine area is within a zone of high strain that is evident in the lithologies that have been mapped and examined during this study which include, chlorite – sericite schist, amphibolite, and granite all of which are cataclastic to mylonitic and situated within discrete to widespread shear zones. Heterogeneous strain gradients are evident across the strike of the units in the Hab area**.** Granite bodies lie on either side of the Hab Mine area and are considered the main precursors for the complex array of faulted and sheared rocks in and around the mineralized zone(s).

Methods

Whole-rock compositions were analyzed using X-ray Fluorescence (XRF) on 20 samples across selected uranium-mineralized zones within the Hab Mine and 46 Zone areas. The XRF dataset includes all major and trace element concentrations, including U, expressing these concentrations as wt% oxide and ppm, respectively. Systematic sampling across the uranium-mineralized zones was conducted in order to include the spectrum of progressive alteration. Rocks sampled distal from the main uranium-mineralized zones are considered to be fresh, i.e., the best representative parental compositions of their uranium-mineralized equivalents taken from within the main ore zones of the Hab Mine area and 46 Zone. ‘Fresh’ samples were then plotted along with uranium-mineralized samples of the same rock type analyzed from within these zones. Changes in mobile major- and trace-element concentrations can be correlated to the alteration processes that the host rock compositions underwent during the mineralizing event(s). Alteration was assessed using alkali-alumina ratios and the methods described by Davies and Whitehead (2006) (Figs. 2 & 3). The use of such bivariate X-Y plots allows for the classification and correlative comparison of the alteration mineralogy, i.e., albitization, chloritization, and sericitization, with the associated uranium content for that zone. Mineral composition and identification has, to date, only been obtained exclusively on the Hab Mine samples via scanning electron microscopy (SEM).

Discussion

Figure 2 provides results for samples from the 46 zone, whereas Figure 3 provides results for the Hab Mine area. Figure 2A displays alkali-alumina ratios for plagioclase, muscovite, and alumina-bearing ferromagnesian minerals. It exhibits where the 46 Zone unmineralized and uranium-mineralized amphibolite samples plot and thus allows for an inference of particular alteration mineralogy within these rocks. The two samples that plot within the far left-hand corner (red circle), i.e., toward the albite field, contain abundant felsic vienlets that are on the mm(s) scale in hand sample. Uranium mineralization within the amphibolite appears to have an inherent increase in albitization**,** sericitization (Fig. 2B), and chloritization (Fig. 2C) with increasing U-mineralization; Vectors in both Figures 2B and 2C indicate the direction toward the ore zones. With respect to the Hab Mine cataclastic rock samples from the uranium-mineralized fracture region are shown in Figures 3 A, B, and C. Figure 3A illustrates the alkali-alumina ratios for plagioclase, muscovite, and alumina-bearing ferromagnesian minerals; Figure 3B illustrates the alkali-alumina ratio vs. U, and the vector indicates direction of intensifying chloritization with increasing uranium content; and finally Figure 3C illustrates the alumina-bearing ferromagnesian minerals vs. U, with the vector indicating the direction of decreasing chlorite content with increasing uranium content across the mineralized zone. In hand sample the cataclastic granite from the Hab area are fine-grained cataclasite with minor chlorite and sericite. Minor chlorite typically occurs within fine vienlets and fractures cutting the unit and characteristically is associated with fine-grained apatite. Uranium minerals are typically hydrous uranium-lead silicates, such as kasolite, that occur within vienlets containing fine-grained REE carbonates (bastnäsite), and monazite; consistent with covariance of Ce and U, r = 0.23. Fine-grained muscovite (sericite) occurs on boundaries of these vienlets and within feldspar grains.

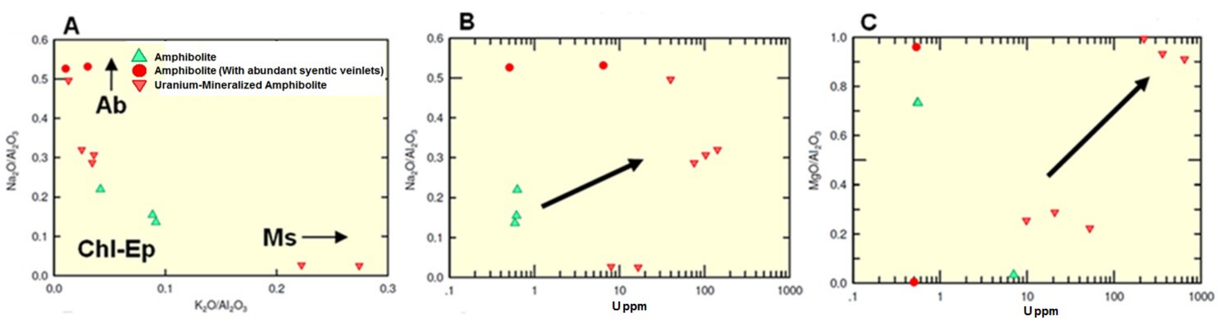

Figure 2: Molar ratio plots for uranium mineralized fracture region within the 46 Zone. A) Alkali-alumina ratios for plagioclase, muscovite and alumina-bearing ferromagnesian minerals. B) Alkali-alumina ratio vs. U. Vector indicates direction of direction of intensifying albitization with increasing uranium mineralization. C) Alumina-bearing ferromagnesian minerals vs. U. Vector indicates the direction of intensifying chloritization with increasing uranium mineralization.

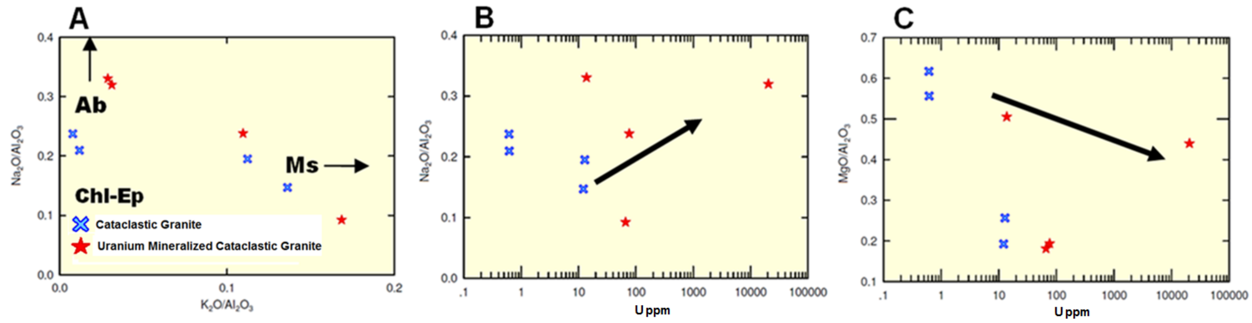

Figure 3: Molar ratio plots for uranium mineralized fracture region within the Hab Mine. A) Alkali-alumina ratios for plagioclase, muscovite and alumina-bearing ferromagnesian minerals. B) Alkali-alumina ratio vs. U. Vector indicates direction of direction of the intensifying albitization with increasing uranium mineralization. C) Alumina-bearing ferromagnesian minerals vs. U. Vector indicates the direction of decreasing chloritization with increasing uranium mineralization.

Conclusions

Alteration of the host rock(s), such as albitization, sericitization, and chloritization, are not generated exclusively during the creation of uranium-mineralized vein systems. For example, albitization, specifically the increase of albite content in peraluminous leucogranite bodies, such as observed in the eastern portion of the Saint Sylvestre leucogranite complex, display a somewhat contemporaneous uranium increase that is related to the incompatible behavior of both U and Na upon crystallization of the melt (Cuney and Kyser, 2009). The ore and alteration paragenesis is consistent with other vein-style uranium mineralization, which is paramount in deciphering the mechanisms for deposit petrogenesis. The uranium mineralized zones at both the 46 Zone and Hab Mine regions are clearly both epigenetic. Having said this, the mineralized zones at 46 Zone and Hab mine differ significantly in terms of host rock composition, alteration mineralogy, and vein compositions.

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