Winnipeg 2013

Technical Program

SS5: Uranium: Cradle to Grave

Supported by / Soutenue par: **Environmental Earth Sciences Division (GAC)**
Organizers / Organisateurs: **Peter Burns, Ginger Sigmon**
Room / Salle: **MR3E**
Date: **Friday, May 24, 2013**
Time: **8:20 AM**
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Major and minor compositions of alteration minerals associated with the uranium mineralization at Phoenix and Millennium deposits, Athabasca Basin, in northern Saskatchewan

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Uranium deposits in the Athabasca Basin occur mainly along the unconformity between the crystalline basement rocks and the overlying mid-Proterozoic Athabasca sandstone. The uranium mineralization is accompanied by extensive alteration forming kaolinite, illite, chlorite and dravitic tourmaline. In addition, the rocks have undergone paleoweathering of the basement rocks and diagenesis of sandstones before the mineralization. To constrain the origin of fluids, we examined major and minor elements including halogens of alteration minerals associated with uranium deposits at the Denison Mine's Phoenix deposit and the Cameco's Millennium deposit. The Phoenix deposit, with 52.3 million lb of U_3O_8, occurs along the unconformity at a depth of 400 m, and the Millennium deposit, with 46.8 million lbs of U_3O_8, along a basement fault at a depth of 750 m.

Samples are representative alteration minerals around the two uranium deposits. Millennium samples are graphitic pelites and pegmatite collected from DDH CX055 at depths from 590.7m to 659.6m. Phoenix samples are sandstones (one at a depth of 168.7m) and basement samples near the deposits. Tourmaline occurs as bluish veinlets in pervasively altered rocks at Millennium and forms coarse grains, up to 10 micrometers. The minerals examined are tourmaline, sudoite from the Milliennium deposit, muscovite from both deposits, kaolinite and clinochlore from the Pheonix deposit. Tourmaline from the Millennium deposit is all magnesiofoitite with an average formula of $(A_{0.73}Na_{0.24})(Mg_{1.89}Fe_{0.047}Al_{0.65})(Si_{5.84}Al_{0.15})O_{18}$ $(OH_{3.94}F_{0.051}Cl_{0.0068})$ where A stands for a vacancy. Muscovite has an average formula of $(K_{1.61}Na_{0.027})(Al_{3.60}Mg_{0.37}Fe_{0.13})(Si_{6.54}Al_{1.44}Ti_{0.023})O_{20}(OH_{3.90}F_{0.099}Cl_{0.0054})$ and those from Millennium has slightly higher MgO (2.27 wt%) and lower FeO (0.93wt%) than that of Pheonix (1.43 wt%MgO; 1.43 wt%FeO), but the overall compositions are similar, suggesting the fluids responsible for muscovite crystallization were similar at two deposits. Clinochlore has an average formula of $(Mg_{4.53}Al_{3.17}Fe_{3.78})(Si_{5.70}Al_{2.30})O_{20}(OH_{15.9}F_{0.052}Cl_{0.0092})$ with sudoite having an average formula of $(Mg_{2.8}Al_{6.3}Fe_{0.095})(Si_{6.88}Al_{1.12})O_{20}(OH_{15.9}F_{0.059}Cl_{0.0059})$, which is distinguished from clinochlore by having a higher Al, lower Fe and lower Mg contents. The contents of Cl in all samples are surprisingly low, mostly 0.04 wt% and up to 0.08 wt% in muscovite and illite. The atomic ratios of F/Cl are overall high, up to 750 and the averages are 7.9 for magnesiofoitite, 58 for muscovite, 13 for illite, 13 for sudoite, 15 for chlinochlore and 10 for kaolinite. The evidence suggests significant F in hydrothermal fluids.