

Mineralogical controls of acid generation and metal leaching at contrasting sedimentary exhalative sulphide deposits in the Yukon Territory, Canada

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The Anvil District and the Howard's Pass area of respectively central and southeastern Yukon Territory, Canada, are renowned for their stratiform Zn-Pb deposits. Both camps are located within the Selwyn Basin and the prevalent Zn-Pb deposits are all interpreted to be sedimentary exhalative (SEDEX) in origin. The Anvil deposits are pyrite-rich and have undergone significant regional and contact metamorphism. Recrystallization during metamorphism has resulted in an increase in average grain size and the conversion of the associated carbonates into calc-silicates and some of the pyrite into pyrrhotite. These have in turn effected a reduction in acid buffering capacity and a partial enhancement of sulphide reactivity in the host rocks, which are not fully compensated for by a decrease in specific surface area derived from the coarser grain size. Consequently, acid mine drainage and metal leaching have plagued the mining development both during active mine operation and site decommissioning. In contrast, the Howard's Pass deposits contain less pyrite (25%) and exhibit well-preserved sedimentary structures. The abundance of carbonates within and surrounding the sulphide deposits provides most of the country rocks with an inherent acid neutralization potential. Limited metal leaching (mainly zinc and cadmium) in the mineralized zones occurs as a result of galvanic interaction among the prevalent sulphide minerals. Natural acid rock drainage has been observed only in overlying black shale units with little carbonates. Given the differences in detailed mineralogy and sulphide oxidation mechanisms, it would appear that the Howard's Pass deposits could be exploited with less significant environmental impacts than the Anvil deposits if proper planning and precautionary measures are taken.

Variations in $^{238}\text{U}/^{235}\text{U}$ ratios in natural uranium ore minerals from sedimentary basins

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Current investigations indicate that uranium isotopes fractionate as a result of nuclear volume effects predicted by Bigeleisen in his initial calculations of natural isotopic variations in minerals [1]. More recently, it has been suggested that $^{238}\text{U}/^{235}\text{U}$ ratios will vary as function of uranium oxidation state and will be the highest in reduced species [2].

Uraninite from sedimentary basins is susceptible to recrystallization, reprecipitation and alteration to a variety of secondary uranium minerals that are often produced by interaction with oxidizing fluids. This interaction should therefore be reflected in the observed $^{238}\text{U}/^{235}\text{U}$ ratios.

The $^{238}\text{U}/^{235}\text{U}$ ratios of uranium minerals from sandstone-hosted and calcrete-type uranium showings and deposits worldwide have been measured by multi-collector ICP-MS (Neptune) and reported relative to uraninite from the McArthur River unconformity-related deposit in Saskatchewan, Canada. The total variation of the $\delta^{238}\text{U}$ values during measurement of the in-house standard is ± 0.15 per mil, whereas the total variation of $\delta^{238}\text{U}$ values for uranium minerals is 1 per mil. As predicted, uraninites with the lowest apparent ages, and have suffered repeated recrystallization [3], have the highest $\delta^{238}\text{U}$ values as a result of ^{235}U loss during interaction with oxidizing fluids. Additionally, more oxidized secondary minerals have lower $\delta^{238}\text{U}$ values. In conjunction with Pb isotopes and uraninite geochemistry, uranium fractionation could potentially be used in the study of uranium deposits and as an exploration tool.

- [1] Bigeleisen (1996) *J. Am. Chem. Soc.* **118**, 3676-3680.
[2] Schauble (2007) *Geochim. Cosmochim. Acta* **71**, 2170-2189. [3] Alexandre and Kyser (2005) *Can. Mineral.* **43**, 1005-1017.