

## **Controls on uranium, rare earth element, and radionuclide mobility at the decommissioned Bicroft Uranium Mine, Ontario**

M.B. PARSONS<sup>1\*</sup>, P.W.B. FRISKE<sup>2</sup>, A.M. LAIDLAW<sup>3</sup>  
AND H.E. JAMIESON<sup>3</sup>

<sup>1</sup>Geological Survey of Canada (Atlantic), Dartmouth, NS  
(\*correspondance: Michael.Parsons@NRCan.gc.ca)

<sup>2</sup>Geological Survey of Canada (Northern), Ottawa, ON

<sup>3</sup>Queen's University, Kingston, ON

Uranium ores have been mined in Canada since the 1930s, resulting in the production of approximately 214 million tonnes of mill tailings. These tailings may pose a risk to ecosystems and human health because of their long-lived radioactivity, and their potential to release radionuclides, metal(loid)s, radon gas, and milling reagents to the environment. The main objective of this study was to characterize the processes controlling the release, transport, and fate of U, radionuclides (<sup>226</sup>Ra, <sup>210</sup>Pb), and rare earth elements (REEs) downstream from two decommissioned tailings impoundments at the Bicroft Uranium Mine near Bancroft, Ontario. Samples of tailings, sediments, surface waters, and colloids were collected from the Bicroft Mine between 2010 and 2012. Regional-scale sampling of sediments and waters was undertaken to determine natural background variation. The concentration of U in the Bicroft tailings samples varies from 3.1 to 210 mg/kg (median 19 mg/kg). Much higher concentrations were found in stream and pond sediments below the tailings impoundments (54 to 730 mg/kg; median 150 mg/kg). Uranium concentrations in regional lake sediments range from 0.4 to 140 mg/kg (median 4.2 mg/kg). Seasonal sampling of tailings effluent shows that these waters are circumneutral (pH 6.6–8.3) and that the downstream concentrations of U and <sup>226</sup>Ra are generally highest in the fall. Comparison of filtered and unfiltered effluents, combined with synchrotron microanalyses of colloids, shows that the downstream mobility of REEs is limited by sorption to Fe- and Mn-oxyhydroxides. In contrast, U occurs mainly in the dissolved phase and its mobility does not appear to be limited by sorption to colloids or precipitation of secondary U phases. Geochemical modeling of the effluent demonstrates that the aqueous speciation of U is dominated by calcium-uranyl-carbonato complexes, which may limit sorption of U to mineral surfaces and suppress the reduction of U(VI) to less soluble U(IV). The results of this study provide improved understanding of the long-term stability of U tailings, and have implications for the design of environmental monitoring plans.