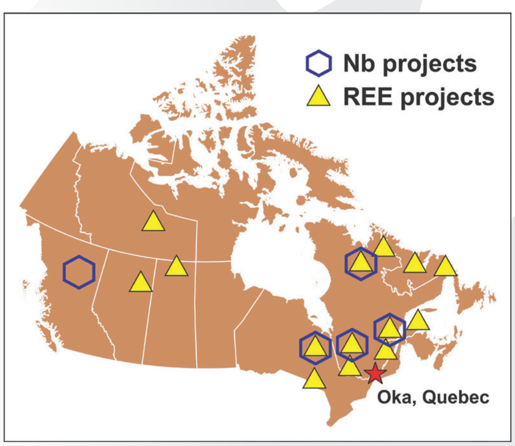
Geoenvironmental characteristics of critical metal deposits

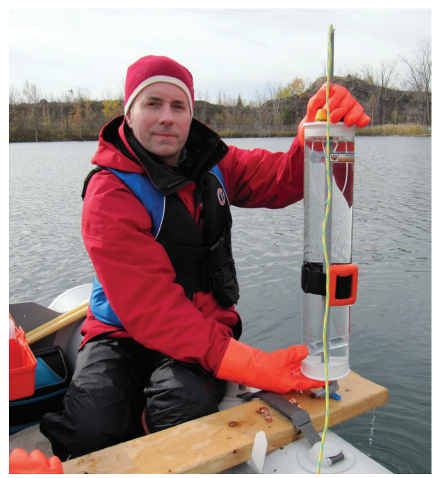
In recent years, there has been a rapid increase in the global demand for many elements used in green energy and high-tech applications. The elements include antimony (Sb), cobalt (Co), indium (In), lithium (Li), niobium (Nb) and the rare earth elements (REE). These materials are used in a broad range of devices, including hybrid vehicles, photovoltaic cells, rechargeable batteries, mobile telephones, LCD screens, wind turbines and medical imaging equipment.

The term "critical metal" refers to elements that are essential for modern technology, but whose supply is at risk because of geological scarcity, political control of exports, low recycling rates or concerns over the environmental impacts of mining. Canada has abundant resources of these critical metals, and many companies are working hard to bring new mines into production. However, we know very little about the potential environmental impacts of mining critical metals compared to mining other commodities such as gold or copper.

Processing resources such as REEs has led to environmental degradation in some parts of the world, but there are few published studies of these environmental impacts and related risks to human health. Recent studies in Quebec by the Geological Survey of Canada (GSC) are providing new geoscience knowledge on the geoenvironmental characteristics of Nb and REE deposits. This knowledge should help to reduce the environmental risks of future development of these important resources.



Location of Nb and REE exploration and development projects across Canada. At present, one Nb mine operates in Saint-Honoré, Quebec. There are no REE mines in Canada.



Kemmerer sampling bottle used to collect water at depth in the flooded open pits

St. Lawrence Columbium mine

The abandoned St. Lawrence Columbium mine in Oka, Quebec, operated from 1961 to 1976 and, at the time, was one of the largest Nb producers in the world. Most of the Nb and REE minerals at this site are hosted in carbonatite, a relatively rare igneous rock. Geologically, the deposit at Oka is very similar to several other carbonatite deposits across Canada that are being considered for mining of Nb and REEs. Niobium ore was extracted by using open pit and underground mining methods, processed on-site, and sold mainly for use in steel production. Today, the mine site is inactive and contains piles of waste rock, tailings, slag, two flooded open pits, and underground mine workings that are filled with water.

In 2015, 2016 and 2017, GSC scientists collected samples of mine waste, surface water and groundwater to better understand the distribution, transport, and fate of metals and radionuclides. A hand-held gamma-ray spectrometer was used to measure the radiation emitted by decay of naturally occurring uranium (U) and thorium (Th) in the mine waste. Seasonal variations in water quality are being monitored over two years. The equipment being used includes data loggers installed in the flooded pits, sampling equipment that can collect water to a depth of 100 metres (m), and instruments installed in groundwater wells.

Key findings

1. About half of the St. Lawrence Columbium mine site is covered in tailings, which are a sand-sized waste from milling Nb ore. Analysis shows that the tailings are enriched with Nb and REEs, but have relatively low concentrations of potentially hazardous elements, including U, Th and naturally occurring radioactive isotopes (e.g. radium-226, lead-210).

2. In contrast, smelter slag at the mine site contains high concentrations of U, Th and radioactive isotopes that exceed Canadian guidelines for the disposal of radioactive waste.

3. Analysis shows that mine site surface waters are weakly alkaline and contain very low concentrations of Nb, REEs, U, Th, radium-226, radium-228 and lead-210. The concentrations of these elements are slightly higher in low-oxygen water deeper than 30 m in one of the flooded open pits. These results suggest that potentially hazardous elements in the local bedrock and mine waste are relatively immobile in well-oxygenated surface water but may be transported in deeper, low-oxygen groundwater.

Hand-held gamma-ray spectrometer used to measure the radioactivity of mine waste

Photomicrograph of carbonatite from Oka, Quebec. Mineral assemblage includes niocalite (yellow), calcite (white), perovskite (black) and apatite (grey). Field of view is 1 cm. Photo: T. Peterson, GSC.

Making a difference

The long-term goal of this project is to help expand Canada's role as an environmentally responsible supplier of critical metals. More studies are underway at the St. Lawrence Columbium mine. These will investigate seasonal variations in water chemistry, the long-term stability of mine waste, and the key processes controlling the composition of local surface water and groundwater. Results will be shared with the Municipality of Oka to help with long-term management of the mine site. The results will also help industry and regulators to improve environmental predictions for future Nb- and REE-mining projects and to support developing new environmental guidelines.

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