Canada’s critical minerals research in building its future economy

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Mostafa Fayek, Distinguished Professor at the University of Manitoba, discusses the significance of critical minerals (CMs) in modern technology and national security, highlighting their essential role in Canada’s economy and energy transition

When you pick up your smartphone or plug in your laptop, you’re holding the product of geology in your hands. Behind the screens and batteries are a group of little-known but incredibly important resources called critical minerals or metals (CMs). But what makes a mineral ‘critical’?

A critical mineral is one that is essential to a country’s economy, national security, or energy transition – but one whose supply is at risk (National Research Council, 2008). The minerals considered ‘critical’ change over time, depending on technology and demand. For example, salt was once considered a critical mineral due to its importance in food preservation, and aluminium was once regarded as a rare and precious metal. Today, most critical minerals are linked to high-tech industries.

For example, lithium (Li) is used to make heat-resistant glass, ceramics, lubricants, and flux additives in metal production. Most importantly, it is the key ingredient in rechargeable batteries that power smartphones, laptops, digital cameras, and electric vehicles. Demand for lithium is rising rapidly as the world pushes toward renewable energy and green technologies.

Canada and the critical mineral industry

Canada is rich in natural resources, including many of the minerals considered critical today. On March 11, 2021, the Government of Canada published its official list of 31 critical minerals (nrcan.gc.ca). These include lithium, copper, cobalt, nickel, and rare earth elements (REEs), all of which are found within Canada’s borders.

In December 2022, Canada released its Critical Minerals Strategy, identifying six priority elements – lithium, carbon, nickel, cobalt, copper, and REEs – as the most important for economic growth and strategic supply chains, such as semiconductor and clean-energy manufacturing.

Provinces are also stepping up. In the summer of 2023, Manitoba published its own strategy, highlighting four critical minerals to prioritize: lithium, copper, nickel, and silica. These provincial and federal strategies build on the Canadian Minerals and Metals Plan (MinesCanada.ca, 2019), which sets the framework for developing Canada’s mineral resources to support national security, economic growth, and green energy.

What this means is simple: Canada must remain competitive in discovering, mining, and processing critical minerals. Reducing reliance on imports will help ensure that Canada has stable, environmentally responsible supplies to support its growing technology, manufacturing, and clean energy sectors.

Exploring for critical minerals

Finding new deposits of critical minerals is not easy. In Canada, these elements are often associated with unusual rock formations created in the Earth's crust as molten rock cools and solidifies (Bowell et al., 2020).

Specifically, critical minerals are frequently found in rocks formed during the late stages of magma crystallization. As magma cools, certain elements are left behind in the molten residue, concentrating in pockets that can host rare and valuable minerals. Pegmatites and specialized granites are examples of rocks that can contain minerals like spodumene, lepidolite, beryl, petalite, and columbite-tantalite, all of which are important sources of lithium, niobium, tantalum, and other CMs (Černý et al., 1985; London & Evensen, 2002; Breiter et al., 2006; Chudík et al., 2008; Merino et al., 2013).

These rocks can also contain exotic minerals enriched in rare earth elements, tungsten, and uranium. However, not all granites are the same. Some are enriched in lithium and beryllium, while others contain uranium, silver, or antimony. This 'metal specialization' makes exploration complex (Cuney et al., 1992; Raimbault et al., 1995).

Adding to the challenge, many of the foundational studies on these rocks were done more than 35 years ago, focusing mainly on mineral descriptions rather than exploration models. As demand for CMs rises, Canada urgently needs new research to understand how these mineral systems form and where best to find them.

New and innovative exploration methods

Recognizing this need, Canada launched a research funding program in 2022 through the Natural Sciences and Engineering Research Council (NSERC). The goal is to develop innovative exploration tools to identify and evaluate critical mineral deposits.

At the University of Manitoba, two major research programs in critical minerals began in 2023.

The first is a Critical Metals Consortium, led by Distinguished Professor Mostafa Fayek from the Department of Earth Sciences. This project brings together researchers from the University of Manitoba, Lakehead University, and three industry partners – Snow Lake Lithium, New Age Metals, and Grid Metals. The consortium focuses on building new exploration models for lithium-bearing systems in Manitoba and northwestern Ontario, regions with enormous untapped potential.

The second program is led by Dr Colin Gilmore, Canada Research Chair in Applied Electromagnetic Inversion in the Price Faculty of Engineering. Partnering with EarthEx, this team is developing advanced Canadian-made sensors to explore for minerals in ways that

reduce environmental impacts. These sensors can help geologists ‘see’ into the Earth without the need for widespread drilling, lowering both costs and ecological footprints.

Why this research matters

The outcomes of these projects will have national and international significance. Federal and provincial energy and mines departments will be able to expand databases of CM resources, while exploration companies can apply these models to identify prospective areas and invest in new projects. This translates directly into economic growth, job creation, and increased global competitiveness for Canada’s mining industry.

For Manitoba specifically, a deeper understanding of lithium systems will support new exploration and development in the province, positioning it as a key supplier in the global clean energy supply chain. Improved exploration techniques – sometimes called ‘vectoring tools’ – will also shorten the time and money companies spend in the early stages of exploration, making Canadian projects more attractive to investors.

Importantly, the benefits extend beyond Canada’s borders. Because these exploration tools are based on fundamental geological principles, they can be applied worldwide. Canadian companies working abroad will be able to use the same models, enhancing Canada’s reputation as a global leader in sustainable mineral exploration.

Building Canada’s future

Critical minerals are the building blocks of smartphones, renewable energy systems, and national security technologies. As the world transitions toward a low-carbon economy, the need for stable and responsible supplies of lithium, nickel, copper, cobalt, and rare earths will only increase.

Canada has the natural endowment to be a leader in this global shift – but only if it continues to invest in research, innovation, and responsible exploration. The projects underway at the University of Manitoba and across the country show that Canada is taking this challenge seriously.

By developing the tools to find and responsibly mine critical minerals, Canada is securing its economic future, reducing its dependence on imports, and contributing to a greener, more sustainable world.

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