Gearing Up for the EV Transition: **The Canadian Mining Industry**

2019-2023

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APRC Automotive Policy Research Centre

About the APRC

The Automotive Policy Research Centre (APRC) conducts research and disseminates knowledge about the role of public policy in supporting Canada's globally competitive automotive industry.

The APRC was formed in 2012 as a collaborative research partnership funded by a grant from Automotive Partnership Canada (APC). Between 2012 and 2018, the APRC engaged university-based researchers, policymakers, and industry stakeholders from Canada and abroad in a variety of research collaborations, resulting in dozens of publications, presentations, and events.

In 2018, the APRC became a not-for-profit organization that maintains partnerships with policymakers, industry stakeholders and university-based researchers, one that continues to pursue multi-disciplinary research related to the role of public policy in supporting the automotive industry in Canada.

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Introduction

The transition to sustainable energy is underway and the automotive industry in Canada – and globally - is shifting towards cleaner technologies, including electric vehicles (EVs). This is reshaping production processes, supply chains, and consumer markets. The mining sector is uniquely positioned to play a pivotal role in advancing clean energy technologies, particularly those of EVs. Central to this transition are lithium-ion (L-ion) batteries which power EVs, as well as many other essential technologies such as smartphones, laptops, and solar energy storage systems. As a producer of many of the critical minerals essential to the production of EV batteries, the mining sector in Canada has the opportunity to expand its production to address the growing demand for EVs.

Canadian Mineral Mining Industry At Glance*

GDP [1]	Production [2]	Exports [3]
$27 billion	**$60 billion**	**$51 billion**

*Based on 2023 data

Introduction

With substantial reserves of minerals essential for EV battery production, Canada is well-positioned to develop a domestic EV battery supply chain and supply the North American automotive manufacturing industry. According to the International Energy Agency (IEA), the global demand for critical minerals could quadruple by 2040, with EVs and battery storage accounting for more than 50% of this demand [3]. Canada's approach to capitalizing on this demand is outlined in Natural Resource Canada's (NRCan) Critical Minerals Strategy [4]. This strategy aims to enhance Canada's capacity to mine, process, refine, and recycle critical minerals such as lithium, nickel, cobalt, and graphite—materials vital to the production of lithium-ion (L-ion) batteries.

This report examines the Canadian mining industry, focusing on the minerals and metals used in the production of EV batteries. It explores the materials mined domestically and the contribution of their production to Canada's economy. Although there are many mineral reserves which have been identified and are in early exploration stages, the scope of this report is limited to what is currently being produced by active mines in Canada. The first section of this report identifies key minerals essential to battery manufacturing and places them in the context of Canadian mining. The second section describes Canada's existing production capabilities for six key EV battery minerals. The last section of this report provides an economic overview of the mining and quarrying (except oil and gas) subsector.

Canada is in the early stages of the EV transition and a domestic battery supply chain is developing. This report contains an overview of the mining sector as it relates to the production of minerals specific to EV batteries.

EV Batteries
Characteristics and Chemical Compositions

Currently, lithium-ion batteries are found in the majority of EVs on the market. L-ion batteries are well-suited for this application due to their energy density, efficiency, durability, and reliability. Their high power-to-weight ratio allows them to store a significant amount of energy relative to their size and weight. This makes them ideal for use in compact and weight-sensitive applications such as EVs [5].

There are five main components of an L-ion battery: cathode (positive electrode), anode (negative electrode), electrolyte, separator, and current collectors. The cathode, the most mineral-intensive component, determines the battery's performance, and distinguishes Li-ion battery types. The cathode is made from a combination of lithium metal oxide or lithium carbonate compound, plus other materials such as cobalt, nickel, and manganese. The anode is primarily made of graphite. More recently, silicon-based materials are being used in place of graphite in anodes [6]. The electrolyte consists of lithium salt* in a solvent, with current collectors made of aluminum, copper, nickel, titanium, or stainless steel [7].

Three of the most common battery types used for EVs are LFP (lithium-iron-phosphate cathode), NMC (lithium-nickel-manganese-cobalt cathode), and NCA (lithium-nickel-cobalt-aluminium cathode).

NMC batteries are currently the predominant battery type used in European and American EV markets, although LFP batteries have become increasingly common globally, making up roughly 40% of global EV shares in 2023 [6]. Furthermore, there are several sub-types of NMC batteries, with differing proportions of the same constituent chemicals. NMC 622 and NMC 811 are the most prevalent in EVs and are predicted to become increasingly common [9, 10].

This report focuses on the specific minerals required for these three main battery types within the context of Canadian mining.

Table 1. Comparison of characteristics L-ion batteries

	Cathode Chemical Composition [11]	Lifecycle [12,13]	Energy Density [12,13]	Cost [12,13]	Safety [12,13]
NMC622	Lithium (11%) Nickel (54%) Manganese (17%) Cobalt (18%)	~ 1, 500 cycles	🔋🔋	$ $	✓ ✓
NMC811	Lithium (10%) Nickel (72%) Manganese (9%) Cobalt (9%)	~ 2,000 cycles	🔋🔋	$ $	✓ ✓
LFP	Lithium (7%) Iron (59%) Phosphate (34%)	~ 3,000 - 6,000 cycles	🔋	$	✓✓✓
NCA	Lithium (11%) Nickel (74%) Cobalt (14%) Aluminum (1%)	~ 500 cycles	🔋🔋🔋	$$$	✓

* Lithium salts are a derivative of lithium

Canadian Mining EV Battery Materials

Of the materials required to produce L-ion batteries, the following are products of Canadian mines: lithium, nickel, cobalt, graphite, iron, and copper. All these minerals have been identified by the Canadian government as critical to the establishment and security supply chains necessary for the transition to a low carbon economy [4].

Cobalt

All of Canada's cobalt is a secondary product of nickel mining. Globally, 98% of all cobalt is a by-product of copper or nickel mining [14]. There are no mines in Canada that exclusively produce cobalt.

→ Number of Active Mines *

15

→ Quantity Produced (recoverable) (2023)

5,100 t

→ Value of Shipments (2023)

$ 290 million

Lithium

Lithium is mined from hard rock (spodumene) or brine, with spodumene processed into lithium carbonate or hydroxide, while brine yields lithium carbonate. Both methods are utilized in Canada. Oversupply and decreases in global lithium prices have prompted miners worldwide to reduce or suspend production in the near term [15, 16].

→ Number of Active Mines

2

→ Quantity Produced (2023)

179 t

→ Value of Shipments (2022)

< $3 million **

Graphite

Graphite is found in every battery anode that enables the storage of lithium ions. In most EV batteries, graphite is the largest material by mass. Synthetic graphite is becoming common in EVs in China and production facilities are often easier to set-up than facilitating a new mining site.

→ Number of Active Mines

1

→ Quantity Produced (2023)

5,700 t [17]

→ Value of Shipments (2023)

$ 18 million

* APRC estimate as of December 2024.
* Mines may produce more than one type of mineral, so the same mine might be included in the count for more than one mineral type.
** Author's estimates.

Canadian Mining

EV Battery Materials

Iron

LFP batteries are the only type of L-ion battery that uses iron in its chemical make-up. In LFPs, iron replaces nickel and cobalt in the cathode of the NMC battery which considerably reduces the overall cost of the battery [18].

Number of Active Mines

8

Quantity Produced (concentrates) (2023)

59 million t

Value of Shipments (2023)

$ 6 billion

Nickel

As of 2023, NMC and NCA battery cathode chemistries, which both require nickel, accounted for 60% of all EV sales. [19]. The number rises when excluding China, where LFP batteries dominate a large EV market. In North America and Europe, nickel-based cathode chemistries still account for 92% and 79% of EV sales, respectively [20].

Number of Active Mines

15

Quantity Produced (2023)

159, 000 t

Value of Shipments (2023)

$ 4 billion

Copper

Copper is crucial for electric vehicle (EV) batteries, including copper foil as a separator. Despite automakers reducing copper intensity, demand is projected to remain stable with battery electric vehicle (BEV) adoption. BEVs (83 kg) use more copper than hybrid electric vehicles (HEVs, 40 kg) and plug-in hybrid electric vehicles (PHEVs, 60 kg). [21],[22]

Number of Active Mines

26

Quantity Produced (recoverable) (2023)

508,000 t

Value of Shipments (2023)

$ 5 billion

Despite large reserves of manganese and phosphate in Canada, there are currently no active mines. Aluminium is not mined directly, Bauxite and alumina are imported from other countries, the majority from Brazil, Australia, and China [23]. As a result, Canadian aluminum production refers to the manufacturing process rather mined materials.

Source for *Quantity Produced* and *Value of Shipments: Statistics Canada. (2024). Production, shipments and value of shipments of metallic and non-metallic minerals, annual. (Table 16-10-0022-28). Unless noted otherwise.*

Industry Economic Indicators

This section of the report will examine the performance of the Canadian mining sector as reported by Statistics Canada through North American Industry Classification Systems (NAICS) industry codes as well as Trade Data Online from Innovation. Science, and Economic Development Canada [24].

Based on the information summarized in the previous section, Lithium, Cobalt, Graphite, Iron, Nickel and Copper will be included in this economic analysis.

In summary, the mineral industries examined in this report are classified under the following NAICS codes:

Table 2. 6-digit NAIC codes for selected mineral industries

Mineral	6-digit NAICS Code(s)
Cobalt	212299 - All other metal ore mining
Lithium	212398 - All other non-metallic mineral mining and quarrying
Graphite	212398 - All other non-metallic mineral mining and quarrying
Iron	212210 - Iron ore mining
Nickel	212232 - Nickel-copper ore mining
Copper	212232 - Nickel-copper ore mining 212233 - Copper-zinc ore mining

At the two-digit NAICS level, all mining operations in Canada are aggregated at the sector-wide NAICS code 21. Three-digit NAICS codes represent industry groups that are slightly more disaggregated. For this report, the relevant three-digit NAICS code is 212 (mining and quarrying, except oil and gas). Four-digit NAICS codes are disaggregated further and six-digit NAICS codes represent the most specific industrial classification (specific mineral production, for this report). It is important to note that even at the most detailed NAICS level, some sub-sectors include more than one mineral. Also, data might not be available at the six-digit level if the industry is small.

Production

Tables 3 and 4 show the quantity of each mineral produced in Canada, as well as the value of those shipments and the quantity shipped. Together, this data provides some insight into the value and quantity of mineral shipments vs the amount produced. All material production decreased during the COVID-19 pandemic years, but the timing and magnitude of impacts were not consistent among mineral industries. For example, copper, iron, and graphite production increased from 2019 to 2020 while cobalt and nickel production decreased. Cobalt production has recovered to pre-pandemic levels, but nickel production has not.

The pandemic offers a partial explanation for production dips during the past five years, but other supply and demand dynamics influence output levels as well. In 2021, the TANCO mine in Manitoba began producing lithium; up until then, Canada had produced a very limited amount of lithium [15]. Conversely, global oversupply of nickel from East Asia has led some Canadian producers to reduce output until market conditions become more favourable [25].

Table 3. Annual production of metallic and non-metallic minerals (tonnes), 2019-2023

	2019	2020	2021	2022	2023
Cobalt, recoverable (tonnes)	5,000	4,100	4,000	3,500	5,100
Copper, recoverable (tonnes)	557,00	582,000	510,000	510,000	510,000
Iron, concentrates (tonnes)	56,400,000	60,650,000	58,300,000	65,000,000	60,000,000
Lithium, recoverable (kilograms)	0	0	85,000	180,000	180,000
Nickel, recoverable (tonnes)	176,000	168,000	160,000	120,000	159,000
Graphite (tonnes)	4,300	16,000	9,300	2,500	5,700

Source: Statistics Canada. Table: 16-10-0022-01

Table 4. Quantity shipped of metallic and non-metallic minerals (tonnes), 2019-2023

	2019	2020	2021	2022	2023
Cobalt, recoverable (tonnes)	4,700	4,3000	4,000	3,600	4,200
Copper, recoverable (tonnes)	552,000	580,000	510,000	507,000	540,000
Iron, concentrates (tonnes)	36,000,000	42,200,000	37,400,000	41,000,000	48,000,000
Lithium, recoverable (kilograms)	0	0	55,000	116,000	115,000
Nickel, recoverable (tonnes)	173,000	178,000	160,000	120,000	141,000
Graphite (tonnes)	11,000	7,600	13,000	-	-

Source: Statistics Canada. Table: 16-10-0022-01

Production

The value of shipments is tied not only to quantity produced but also to the average price of the material within a given year. For example, when comparing the trajectory of nickel production with value of shipments over the years, annual production was lowest in 2022 but value of shipments remained high. This can in part be explained by a price surge of nickel that occurred in 2022 due to fears of nickel supply disruption resulting from the Russian invasion of Ukraine [26]. It is anticipated that production levels of critical battery minerals will increase as demand for EVs increases.

Table 5. Value of shipments of metallic and non-metallic minerals (thousands of Canadian dollars), 2019-2023

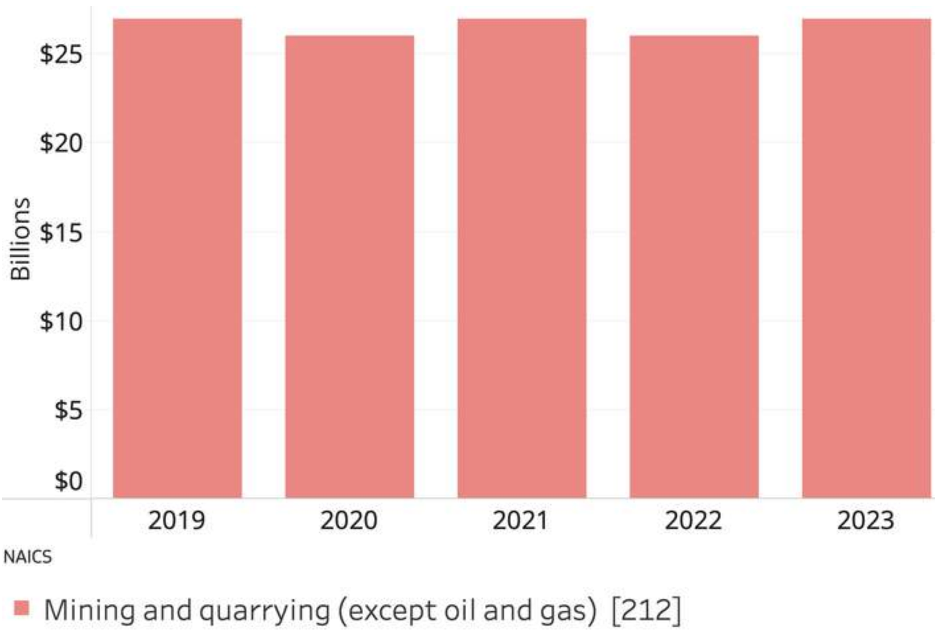
	2019	2020	2021	2022	2023
Cobalt	$180,000	$182,000	$230,000	$270,000	$290,000
Copper	$4,300,000	$4,216,000	$5,600,000	$5,550,000	$5,180,000
Iron	$3,600,000	$5,500,000	$7,000,000	$5,700,000	$6,100,000
Lithium	$0	$0	-	-	$2,100
Nickel	$3,300,000	$3,000,000	$3,300,000	$4,00,000	$4,330,000
Graphite	-	-	-	-	$18,000

Source: Statistics Canada. Table: 16-10-0022-01

GDP

In 2019, NAICS 212 (mining and quarrying (except oil and gas) contributed $27 billion to Canada's GDP. Figure 1 shows that the GDP contribution of NAICS 212 was quite stable between 2019 and 2023. The Covid-19 pandemic in 2020 caused a slight decrease in GDP contribution, to $ 25.5 billion. By 2023, the sub-sector contributed $26.8 billion to Canada's GDP, almost completely recovering to pre-pandemic levels.

Figure 1. Mining and quarrying (except oil and gas) GDP Canada, 2019-2023

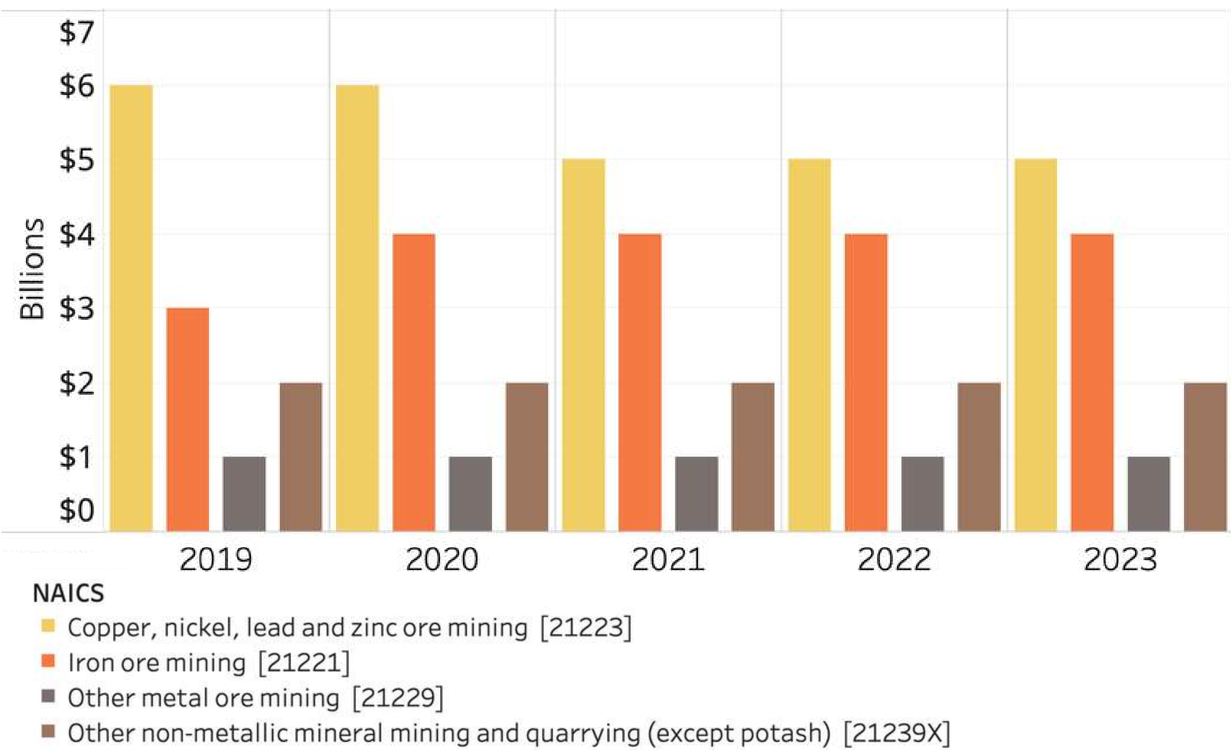


Source: Statistics Canada. Table: 36-10-0434-03

GDP

Figure 2. shows a gradual increase in the strength value of the contribution from NAICS 21221 (Iron ore mining) from 2019 (~$3.4 billion) to 2022 (~$4 billion), followed by a slight decline in 2023 (~$3.8 billion). The GDP contribution of NAICS 21223 (Copper, nickel, lead and zinc ore mining) show a decline of 17.3% between 2019 (~5.8 billion) to 2022 (~4.8 billion) with a modest recovery in 2023 (~$5 billion). The decline may be the result of pandemic related disruptions, supply chain issues, and price fluctuations. The slight recovery in 2023 may in part be in alignment with increasing demand for nickel and copper which are essential for EV batteries and other low carbon technologies[CY1] [EC2] . The declining GDP contribution of NAICS 21229 (Other metal ore mining) due to the pandemic was more pronounced. Dropping from approximately $890 million in 2019 to ~$570 million in 2020 and ~637 million in 2021. The strong recovery in 2023 to over approximately $1 billion, suggests increased demand and value of rare and specialty metals. NAICS 21239X (other non-metallic mineral mining and quarrying (except potash)) saw a decline in 2020 to approximately $1.8 billion from approximately $1.9 billion, in 2019. The increase in 2021 to ~$2 billion may be due to an increase in construction activity as many minerals within this NAICS are used in construction (e.g. Gypsum in drywall and plaster products).

Figure 2. Selected 5-digit NAICS GDP Canada, 2019 - 2023



Source: Statistics Canada. Table: 36-10-0434-03

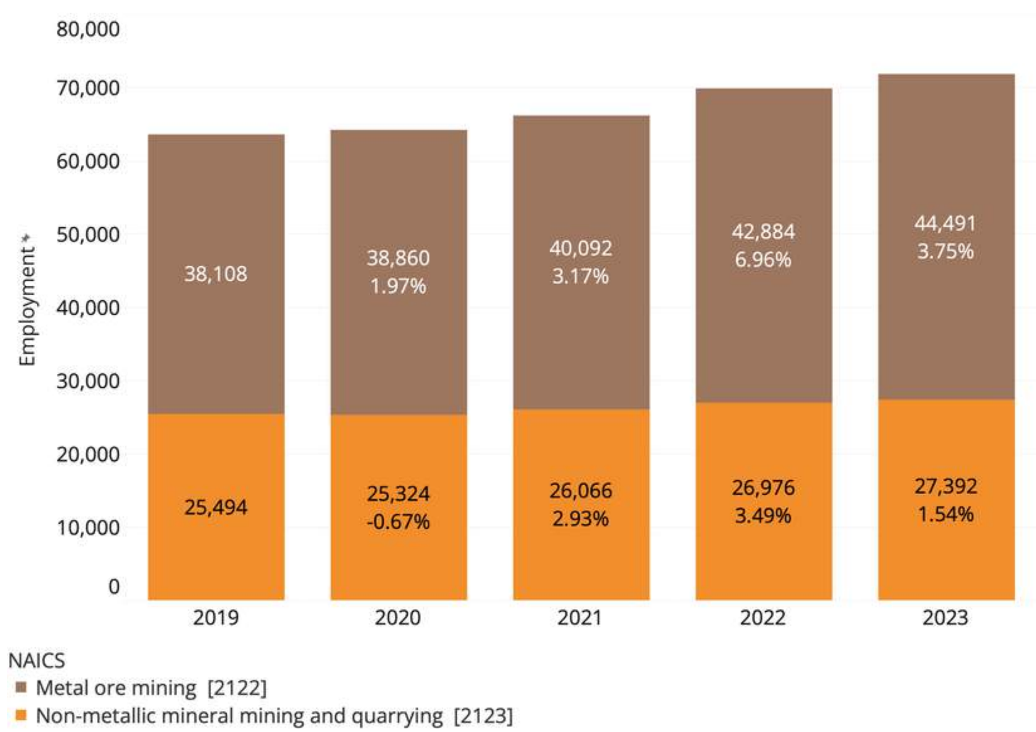
Employment

Measuring employment in the EV-critical mineral mining sector is complicated by the use of broad NAICS classifications, where NAICS 2122 and 2123 include industries beyond battery minerals, such as gold, silver, and stone mining, thus inflating workforce estimates. Additionally, occupational overlap between NAICS 212 (mining) and NAICS 213 (support activities) means that underground production miners and other roles frequently move between these categories, making it difficult to isolate employment trends for critical minerals [27].

Figure 3. illustrates employment growth was broken down within NAICS 2123 (non-metallic mineral mining and quarrying) and NAICS 2122 (metal ore mining). NAICS 2123 shows a small decline between 2019 and 2020, and shows positive growth from 2020 onwards. Employment within NAICS 2122 shows a similarly moderate increase from year to year, with a growth rate that is consistently higher than that of NAICS 2123. The largest increase in employment was seen between 2021 and 2022.

In addition to the complexities of measuring employment in the EV-critical mineral mining sector, Canada's mining industry is confronting a significant labor shortage, particularly in skilled trades. Factors such as an aging workforce and the industry's outdated image contribute to this challenge. Addressing these shortages is essential for the sector's growth and to meet the rising demand for critical minerals in Canada [28]

Figure 3. Non-metallic mineral mining and quarrying and Metal ore mining, annual employment, 2019-2023



Source: Statistics Canada. Table: 14-10-0202-01 (formerly CANSIM 281-0024)

Trade

Tables 6 to 8 illustrate trade statistics for critical battery minerals in Canada. Table 6 shows that NAICS 212233 (copper-zinc mining) and NAICS 212210 (iron ore mining) maintained positive trade balances between 2019 and 2023. The value of imports for both mineral industries suggest that during the pandemic Canada was able to increase exports while keeping imports relatively stable in these industries. For copper this may in part be explained by high demand due to its use in clean technologies, and a reduction in global supply during the Covid-19 pandemic due to disrupted mining operations [29]. Iron ore demand and supply is closely linked to the global steel industry, rising global demand for steel is expected to increase global steel production [30]. It is important to note that these two NAICS trade at levels that far exceed those of the three remaining NAICS.

The consistent trade deficit and steady increase in imports in NAICS 212232 (nickel-copper mining) can largely be attributed to the inability of domestic ore production to meet the demands of Canada's smelters and refineries [31]. In 2021 and 2022, nickel prices increased which further incentivized Canadian smelters to import additional nickel ore, process it, and sell it into a high demand market [32].

Table 6. Trade balance for battery mineral industries (thousands of Canadian dollars), 2019-2023

	2019	2020	2021	2022	2023
NAICS 212233 - Copper-zinc ore mining	**$3,111,300**	**$3,646,200**	**$4,244,850**	**$3,266,600**	**$3,348,000**
NAICS 212232 - Nickel-copper ore mining	**$143,150**	**-$104,300**	**-$315,350**	**-$399,050**	**-$1,010,000**
NAICS 212210 - Iron ore mining	**$5,542,700**	**$6,856,400**	**$9,164,900**	**$7,857,000**	**$7,870,300**
NAICS 212299 - All other metal ore mining (Cobalt)	**-$132,500**	**-$208,550**	**-$170,600**	**-$121,850**	**$34,500**
NAICS 212398 - All other non-metallic mineral mining and quarrying (Lithium, Graphite)	**-$35,500**	**<$1,000**	**$18,600**	**$5,400**	**-$69,100**

Source: Import, Export, And Investment – Industry Canada

Table 7. Battery mineral imports (thousands of Canadian dollars), 2019-2023

	2019	2020	2021	2022	2023
NAICS 212233 - Copper-zinc ore mining	**$651,400**	**$814,000**	**$942,000**	**$1,288,000**	**$972,000**
NAICS 212232 - Nickel-copper ore mining	**$73,250**	**$325,300**	**$463,700**	**$655,150**	**$1,136,000**
NAICS 212210 - Iron ore mining	**$1,022,200**	**$812,000**	**$963,000**	**$938,000**	**$1,100,000**
NAICS 212299 - All other metal ore mining (Cobalt)	**$287,200**	**$298,000**	**$323,200**	**$327,100**	**$432,400**
NAICS 212398 - All other non-metallic mineral mining and quarrying (Lithium, Graphite)	**$137,300**	**$110,200**	**$112,000**	**$137,100**	**$143,000**

Source: Import, Export, And Investment – Industry Canada

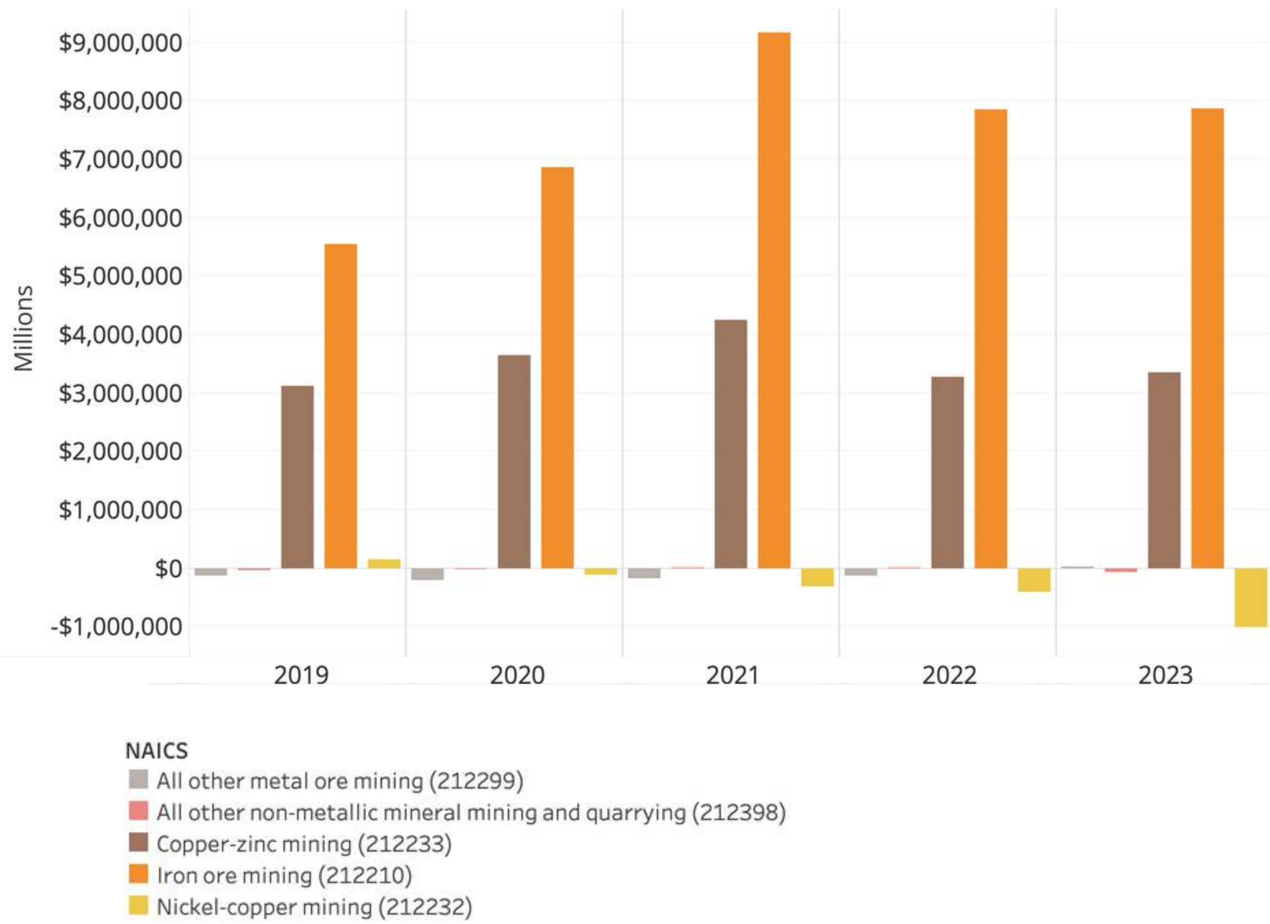
Trade

Table 8. Battery minerals exports (thousands of Canadian dollars), 2019-2023

	2019	2020	2021	2022	2023
NAICS 212233 - Copper-zinc ore mining	**$3,800,000**	**$4,500,000**	**$5,200,000**	**$4,554,000**	**$4,320,000**
NAICS 212232 - Nickel-copper ore mining	**$217,000**	**$221,000**	**$150,000**	**$260,000**	**$126,000**
NAICS 212210 - Iron ore mining	**$6,600,000**	**$7,700,000**	**$10,128,000**	**$8,800,000**	**$8,950,000**
NAICS 212299 - All other metal ore mining (Cobalt)	**$155,000**	**$89,000**	**$153,000**	**$205,247**	**$470,000**
NAICS 212398 - All other non-metallic mineral mining and quarrying (Lithium, Graphite)	**$102,000**	**$111,200**	**$131,000**	**$143,000**	**$74,000**

Source: Import, Export, And Investment – Industry Canada

Figure 4. Battery minerals trade balance, 2019-2023

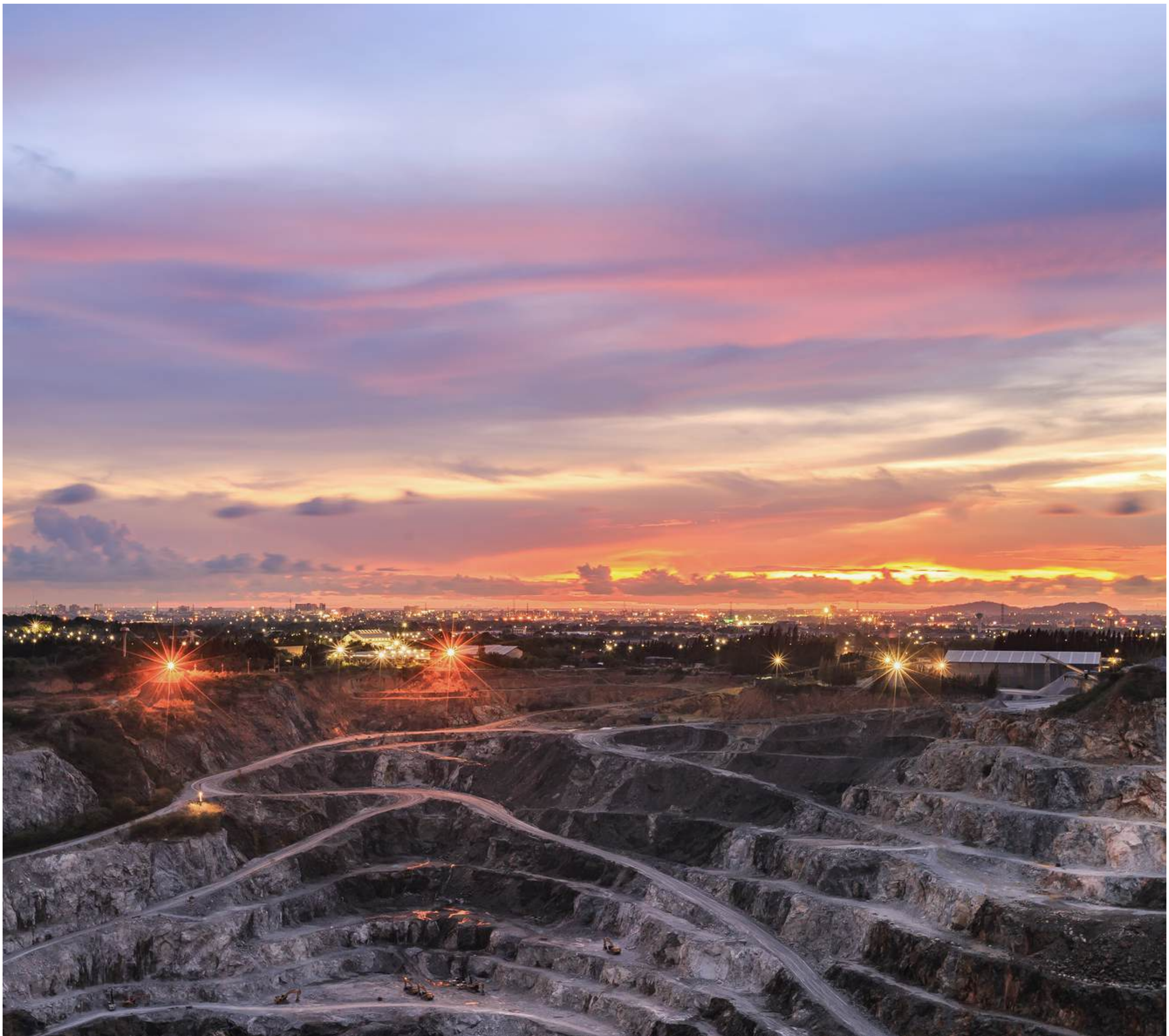


Source: Import, Export, And Investment – Industry Canada

Conclusion

Canada is a leading global producer of many of the minerals key to the transition to clean technologies, specifically EVs. With significant reserves of lithium, nickel, cobalt, and graphite, Canada could be well-positioned to build a domestic EV battery supply chain. In order to achieve a successful and resilient domestic supply chain, Canada will have to build on its strong resource base with ongoing industry investment and adequate policy support.

Mineral production is Canada has historically exported many of these raw materials to other countries such as the United States, China, and Japan. As the demand for these critical minerals grows, the importance of a secure, reliable supply chain has become clear. By focusing on developing its mineral mining sector, Canada could become a global supplier of responsibly sourced minerals, with domestic refining and processing capabilities, all of which support the national and global transition to clean technologies that rely on these essential materials.



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