UVic Sustainability Scholars Program

Is this a Just Transition?: Indigenous Perspectives on Critical Minerals in the Energy Transition

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Disclaimer

This report is a product of the UVic Sustainability Scholars Program, a partnership between UVic and various on - and off-campus organizations offering internship opportunities to graduate students working on sustainability-focused research projects that advance sustainability in the region. This project was conducted under the mentorship of Serena Mendizabal of Sacred Earth Solar.

Territorial Acknowledgement

I acknowledge and respect the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

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Introduction

Background Context:

Currently, Indigenous Peoples in Canada are the second-largest asset owners of renewable energy across the country, outside of electricity transmission and distribution utilities (Stephenson, 2023). With immense influence in the clean energy sector due to our unique rights and intimate relationship to the land, Indigenous Peoples are active protagonists guiding the Just Transition in Canada by enacting energy sovereignty through capacity-building, small to large-scale generation projects, and equity ownership for long-term community revenue. With that being said, renewable energy continues to rely on extraction to produce electricity through the mining of critical and rare earth minerals. Most, if not all, of the critical minerals in Canada are located on Indigenous territories. For many Indigenous Peoples, connection to the land and waterways embeds and informs culture, self-identity, community, belief systems, livelihoods, and traditional governance. The territories that are being mined in the name of low-carbon economies and greenhouse gas-reducing projects are the territories that influence every aspect of our lives and identity as Indigenous peoples. Hence, protecting Indigenous lands is not only a measure of sustainability to meet national targets but also a responsibility, aimed at preserving cultural knowledge and values for present-day communities and future generations. After being purposefully excluded from energy leadership in Canada, Indigenous communities are embracing the energy transition as an opportunity to gain autonomy and are actively building and maintaining renewable energy projects, including solar and wind energy initiatives. While there is openness to collaborating with governments, utilities, and mining firms, many Indigenous Peoples are mindful of the adverse impacts of mineral exploration in their communities, and hesitant around potential greenwashing, continued environmental degradation, and violations against the Indigenous right to free, prior, and informed consent. For many communities to approach projects that align with community values and consent, any projects or policies surrounding the energy transition must emphasize relationships through partnerships that affirm and protect Indigenous Peoples' rights, sovereignty, wisdom, and cultural values. As the energy transition intensifies across Canada, we believe it is essential to take a step back and examine this new energy mix with a critical lens - from source to end use. While there is a national and global demand for the energy transition towards a low-carbon economy, we must ensure a Just Transition that will not compromise Indigenous Peoples' sovereignty, rights, lives and environmental sustainability worldwide. A critical lens will help establish a transition that does not replicate or aggravate the impacts of fossil fuel mining on Indigenous communities. To be sovereign is to be informed, and we must be informed around the evolution of extractivism in the guise of the energy transition within our communities and across our territories.

Project Background

Sacred Earth has been implementing Just Transition efforts for the past ten years through the implementation of Indigenous-led climate and clean energy infrastructure projects, the promotion of energy education and capacity building, advocacy for climate justice and Indigenous sovereignty, and healing justice within frontline Indigenous communities. Sacred Earth focuses on exploring Indigenous-led solutions to equitable climate resiliency while also championing strong, forward-thinking climate advocacy at the regional, national, and global levels. Led and guided by a team of Indigenous women, Two-Spirit and gender-diverse personnel, Sacred Earth ensures Indigenous lived experiences deeply inform our work.

As a component of their energy and capacity-building initiatives, Sacred Earth, in collaboration with Indigenous Climate Action, Power to the People, Real World Media, and the David Suzuki

Foundation, developed the *Just Transition Guide* ("The Guide") which serves as one of our primary resources and accessible contributions to support Indigenous communities and other stakeholders to identify and advance equitable approaches to the energy transition.

The Just Transition Guide aims to safeguard and revitalize Indigenous cultures, languages and traditional knowledge systems to create practical community resilience in response to the climate change crisis in Canada and beyond. Throughout the Guide, Sacred Earth showcases extensive research and case studies shaped by community-identified needs that are directly linked to the principles and priorities of Indigenous-led Just Transition.

Sacred Earth, alongside partners, gathers diverse knowledge, skills and contributions from scholars and community members who offer valuable expertise to support the creation and continuation of the Just Transition Guide, as a public-facing resource. The Sustainability Scholars Program, offered through the University of Victoria, has been a key resource in recruiting scholars to the team. This year, the Scholars Project (#013) focuses on critical minerals as part of a major focus on exploring Indigenous-led pathways to sustainable and equitable climate resiliency and solutions. Scholars also contribute to creating educational resources to support the curricula and training initiatives of the Just Transition Guide. Sacred Earth collaborated with Stanislaus Awini Asaale to support the development of these materials within the Sustainability Scholars Program.

Researcher's Positionality

As an external researcher and scholar for this project, I view this project as an opportunity to apply my research on Indigenous societies and how they navigate the modern world, particularly in the Western context. I am also enthusiastic about climate change, and I am eager to see the significant role critical minerals play in addressing global climate change. Moreover, as an Indigenous person, I am curious to know how the energy transition will affect Indigenous communities, having witnessed the damaging impact of mining on Indigenous Peoples' lands in Ghana, especially relating to their health, environment, sovereignty and ownership rights. This project also offers me the opportunity to add my voice to Sacred Earth's environmentally sustainable goals and highlight the dark side of the energy transition, particularly on Indigenous and vulnerable communities in Canada and globally.

What are critical minerals?

Indigenous relationships to land are rooted in reciprocity, nourishment, and knowledge. So, the concept of natural resources, and the quantification and commodification of our territories, has been a foreign ideology in our communities until recent decades. And while many Indigenous peoples understand critical minerals as a part of the land that embodies their identity and culture, others dilute critical minerals to a resource necessary for economic independence and accelerating the energy transition (Rosewarne, 2024). But, in a world historically premised on natural capitalism, and now intersecting with the inescapable necessity of low-carbon energy sources; countries, corporations, and institutions have defined critical minerals as the key to the transition. Critical minerals are metallic and non-metallic elements essential for energy, the energy transition, economic growth and national security, which are susceptible to disruption because of geological scarcity, geopolitical tensions, trade policies, and supply chain vulnerabilities (Raju, 2020).

In relation to natural capitalism, a mineral is classified as "critical" based on its relevance and contribution to a country's economic growth and energy transition. For instance, in the United

States, a critical mineral is defined as any non-fuel mineral, element, substance, or material that the Secretary of Energy, a federal department, determines as having a significant risk of supply chain disruption, and plays a vital role in one or more energy technologies, including technologies used in energy production (United States Energy Act, 2020). In Canada, critical minerals are classified based on how they impact economic growth and security, the energy transition, and the country's digital economy (Critical Minerals Strategy, 2022). The British Columbia First Nations Critical Minerals Strategy (2024) describes critical minerals as natural resources essential for life and civilization. Critical minerals are also characterized by their limited sustainability in high-technology applications, their geographically uneven distribution of reserves, and their susceptibility to fluctuations in the global geopolitical and economic landscape (Bhamra et al., 2025; Hayes & McCullough, 2018).

According to the World Economic Forum (May 2023), critical minerals are fundamental to modern technology as the world revolves towards electric vehicles and renewable energies. Furthermore, Ash (2024) posits that critical minerals play a crucial role in facilitating the energy transition, describing them as indispensable to the manufacturing and implementation of green technologies. Reich & Simon (2024) also argue that critical minerals are pivotal to sustaining the supply chain needed for the transition to a carbon-free society. Climate Forward (FWD) Canada (2025) characterizes critical minerals as naturally occurring elements and minerals essential to contemporary economies, particularly for high-tech, clean energy, defense technologies, and industrial uses. The article further adds that minerals are deemed critical not only based on their relevance but also due to their supply risks, as many of them are found in a limited number of countries, making their availability susceptible to geopolitical or economic disturbances. Hine et al. (2023) describe critical minerals as high-tech or green metals due to their crucial role in advanced and environmentally friendly technologies. Critical minerals are also commonly referred to as “transition minerals” due to their use in renewable energy sources (Hine et al., 2023). Critical minerals also play a vital role in the green and digital economy, forming the essential components in products such as wind turbines, solar panels, electric vehicles, drones, satellites, smartphones, laptops, data centers, and mobile networks, security, transport, and medical technologies, highlighting their relevance in industry applications, modern technologies and energy transition (Wang et al., 2023).

The definition of critical minerals is dynamic, mostly aligning with a country’s strategic and economic goals (Kondrashov, 2023). Each country’s description, valuation and evaluation of critical minerals depend on the mineral’s contribution to the country’s economic growth, energy transition and impact on the quest for a low-carbon economy. Minerals are classified as critical by industry and policymakers not only because of their essential role in advancing green technologies but also because of economic factors and energy transition (Brown et al. 2024).

What are Rare Earth Minerals?

Rare earth minerals are a group of seventeen metallic elements made of fifteen lanthanides, scandium and yttrium, which are essential components in high-tech devices such as cellular telephones, computer hard drives, and electric and hybrid vehicles (International Union of Pure and Applied Chemistry, 2005; Suli et al., 2017; United States Geological Survey). Rare earth minerals are also used in defense technologies such as electronic displays, guidance systems, lasers, radar and sonar systems (Zepf, 2013).

Surprisingly, rare earths are not as scarce as the name might suggest. Research shows they are abundant globally (Weng et al., 2015). 'Rare' in this context, however, indicates that they are in concentrated deposits, which makes their extraction and refinement complicated and expensive (Brown et al., 2024; Weng et al., 2015; Zepf, 2013). For instance, it is noted that the installation of one wind turbine requires about five hundred pounds of rare earth minerals (Beiser, 2024, p. 26). McLellan et al. (2016) note that neodymium and dysprosium are used to produce permanent magnets that are used for wind turbines and electric vehicles.

Despite their limited supply, these minerals have crucial industrial uses and are indispensable to the development of modern defense systems, green technologies, and electronic applications, crucial for renewable energy technologies (Weng et al., 2016).

Rare earth minerals have strong magnetic capabilities, electrical conductivity and corrosion resistance, highlighting their relevance in industries and applications (Zepf, 2013). For example, rare earth minerals help increase the magnetic properties and general performance of solar panels (Hine et al., 2023). Rare earth minerals also play significant roles in the global economy, drawing significant attention to the countries that possess and produce them, with China, Russia, Canada, Australia, and Brazil being the leading global producers of rare earth minerals (Brown et al., 2024; Zepf, 2013).

The role of Critical Minerals in the energy transition (Canada and globally)

While our world transitions to renewable energy from fossil fuels, it is essential that we are critical and aware of the impacts of "clean" energy, so we do not replicate the same systems of harm that have been perpetuated from the previous energy era (Mulvaney, 2019).

Critical minerals are essential to industrial and manufacturing sectors such as energy, healthcare, defense, armament and high-tech despite their geologic, geopolitical, and economic disruptions (Bonnet, 2025). The International Energy Agency (IEA) (2021) report further states that critical minerals are pivotal in achieving a low-carbon future, as they help meet the high energy demands of new technologies.

Sadeghi et al (2023) argue that the exploration and utilization of critical minerals have become increasingly essential for the advancement of modern technologies and modern standards of living, shaping economic, environmental, and strategic policy development on a global scale. Wang et al. (2023) add that critical minerals are central to the global decarbonization efforts.

Critical minerals play a vital role in global efforts to transition to low-carbon energy systems as they aim to limit global warming to 1.5 degrees Celsius (Bazilian, 2018). The production of green technologies requires a large-scale extraction of minerals such as cobalt, copper, lithium, cadmium and rare earth minerals (Zhou & Brown, 2024). Critical minerals exploration is pivotal in advancing modern technologies, maintaining modern standards of living and shaping economic, environmental, and global strategic policies (Sadeghi et al., 2023). It is estimated that by 2050, over 90% energy will depend on carbon-free energy sources such as solar and wind, while the demand for fossil fuels is expected to decline (British Columbia First Nations Critical Minerals Strategy 2024). Political and environmental actors in Western economies have set sustainable goals to reduce greenhouse gas emissions by 2030, aiming to reduce the consumption of fossil fuels in electricity production and transportation (Hammond & Randy, 2022). Critical minerals are central to green technologies such as solar panels, wind turbines and electric vehicles, which are pivotal in national and global decarbonization goals in the energy transition (Brooks et al., 2024; Wang et al., 2023). As Beiser (2024) indicates, critical minerals are needed to build the renewable energy systems that will stave off the biggest bad thing of them all, which is climate change (Beiser, 2024, p. 15).

What is the difference between critical minerals and rare earth minerals?

Stanislav Kondrashov makes a clear distinction between critical minerals and rare earth minerals, clarifying that whilst rare earth minerals are a specific group of seventeen chemically defined minerals, critical minerals are minerals selected based on their economic and geopolitical relevance in the energy transition (Kondrashov, 2023). He further states that this distinction is shaped by their strategic importance within a particular context, such as energy transition, rather than by their chemical composition. Whereas critical minerals are identified by supply risk and vulnerability, rare earth minerals are identified by their chemical properties. In Canada, all rare earth minerals are classified as critical minerals because of their economic importance and supply risk (Natural Resources Canada, 2021). Canada is not a commercial producer of rare earth minerals; however, it has some of the largest rare earth reserves and resources globally, totaling approximately 15.2 million tons (Natural Resources Canada, 2021). Depending on their strategic importance, rare earth minerals can be upgraded to critical minerals, but a critical mineral cannot be classified as a rare earth mineral if it does not originate from the list of seventeen elements.

As the global transition towards green energy and digitalization intensifies, it is essential to understand the distinction between these minerals, as their distinction impacts industrial supply chain strategies and the development of sustainable, carbon-free technologies (Kondrashov, 2023).

How will the use of critical minerals and mining extraction increase with the transition? By how much?

Demand for the minerals necessary for energy transition technologies is predicted to rise at least fourfold by 2040 to meet global climate goals, with particularly high growth for electric vehicle and battery storage-related minerals (Ash,2024; IEA, 2021). For example, it is estimated that the demand for electric vehicles will increase to about one hundred and forty-five units by 2030, amounting to about 7% in the global vehicle fleet (Dou et al., 2023). The International Energy Agency (2021) report further states that critical minerals are pivotal in achieving a low-carbon future, as they help meet the high energy demands of new technologies.

Sadeghi et al (2024) argue that the exploration and utilization of critical minerals have become increasingly essential for the advancement of modern technologies and modern standards of living, shaping economic, environmental, and strategic policy development on a global scale. For instance, the Canadian automotive report notes a significant increase in recent sales of electric vehicles, with sales increasing to about 60 % (Nations Critical Minerals Strategy, 2024). The report projects a surge across the country in the coming years, which will require more critical minerals to sustain the hike. Furthermore, D'Orazio (2024) notes an increased expansion in the critical minerals market due to rising demand and high prices doubling in size to reach three hundred and twenty billion United States dollars in 2022. The International Energy Agency projects that the consumption of metals like copper and nickel will increase many times in the coming decades compared to current levels, stating that markets for critical minerals such as copper, cobalt, manganese, and rare earth metals will grow sevenfold from 2020 to 2030 (IEA, 2021). If member states fully implement energy and climate pledges signed in the December 2015 Paris Agreement, the International Energy Agency expects demand for critical minerals for clean energy to more than double by 2030 and triple by 2040, reaching almost thirty-five million tons yearly (IEA, 2021).

The 2024 ARTIC mining report emphasizes the future crucial role of critical minerals in the energy transition and environmental sustainability. According to the report, the demand for critical minerals is projected to increase by 300% by 2030 and by over 3.5 times the current levels by 2050. The report also states that the demand for copper will increase by 50% by 2040, while nickel, cobalt and rare earth minerals will be twice their current value. The demand for graphite is expected to increase by four times around the same period, because of the high demand for battery deployment for electric vehicles and energy storage.

According to the International Energy Agency, investments in critical minerals increased from 20% in 2021 to 30% in 2022. Investment in this sector is expected to increase significantly soon, as the demand for critical minerals is projected to be more than twice the current demand by 2030 and triple by 2040 (Ash,2024; IEA, 2021). Regarding the value of critical minerals, TD Economics' forecast (Canada) argues that these minerals will play a pivotal role in powering technologies needed to decarbonize, estimating a potential gross value of three hundred billion dollars minimum for six priority critical minerals cited in provincial, territorial, and federal strategy reports. This is expected to contribute over five hundred billion dollars to the GDP from mines and provide significant support for economic reconciliation with Indigenous communities across the country (TD Economics Forecast).

The table below shows the estimated demand and increases for key critical minerals between 2021 and 2040 as recorded in the International Energy Agency (2024a, b, c) Global Critical Minerals Outlook.

Mineral	Demand type	2022	2023	2030	20240	Growth Factor 2021- 2040
Copper	Cleantech demand	5,380	6,311	1,2001	16,343	x 3.04
	Other uses	19,548	19,543	19,127	20,036	x 1.03
	Total demand	24,928	25,855	31,128	36, 379	x 1.46
Lithium	Cleantech demand	38	92	442	1,203	x 31.7
	Other uses	63	73	90	123	x 1.95
	Total demand	101	165	531	1,326	x 13.1
Nickel	Cleantech demand	240	478	1,953	3,381	x 14.1
	Other uses	2,519	2,627	2.802	2,857	x 1.13
	Total demand	2,759	3,104	4,754	6,238	x 2.26
Cobalt	Cleantech demand	36	64	177	260	x 7.22
	Other uses	145	150	167	194	x 1.34
	Total demand	181	215	344	454	x 2.51
Graphite	Cleantech demand	532	1,292	6,013	9,839	x 18.5
	Other uses	3388	3,340	4,406	6,185	x 1.83
	Total demand	3920	4,632	10, 419	16,023	x 4.09
Rare Earths	Cleantech demand	11	16	46	64	x 5.82
	Other uses	67	76	87	105	x 1.57
	Total demand	78	93	134	169	x 2.17

The increasing global demand for critical minerals triggers a rapid global expansion of mining operations to meet the future needs of electric vehicles and renewable energy technologies (Benchmark Mineral Intelligence, 2022). This demand requires the construction of over three hundred mines by 2035. Though these increases signal a positive counter for surging demands of critical minerals, it will be prudent to consider the potential impacts of these increases on Indigenous communities, as they will face significant challenges to protect their lands, their physical and mental health.

How does Canada define Critical/Rare-Earth Minerals?

Canada is one of the leading global producers of critical minerals, with about fifty-six critical mineral mines and twenty-six critical minerals processing facilities (Minerals Strategy Annual Report, 2024). According to the report, there are currently one hundred and fifty-one active mine projects, and ten of them are at the exploration stage. The report adds that Canada spent 1.9 billion dollars on critical minerals exploration in 2023. Canada is also ranked as the country with the capacity to establish a secure, reliable and sustainable battery supply chain, placing top in lithium battery production globally (Critical Minerals Strategy Annual Report, 2024). As the demand for critical minerals increases, we expect to see more mines and processing facilities across the country. Canada's mineral production plays a pivotal role in the global supply of essential critical minerals required for the energy transition, producing minerals such as cobalt, nickel, lithium, and rare earth minerals (Glowing WLG, 2025). Canada is also noted as one of the countries in the Western nations that provides a stable and geographically reliable source of critical minerals crucial for North American energy security and mineral supply chains (Glowing GLW, 2025). The Minister of Natural Resources, Jonathan Wilkinson, states that the energy transition cannot be possible without critical minerals, emphasizing their crucial role in tackling climate change and transitioning to a clean economy (Scott, 2022).

In Canada, the Critical Minerals Strategy classifies a mineral as a critical mineral based on two factors.

1. If the mineral supply chain is threatened.
2. If the mineral can be produced in Canada.

Additionally, the mineral must satisfy at least one of the following conditions:

- The mineral is essential for Canada's economic growth and security.
- The mineral plays a pivotal role in the country's shift toward a sustainable, low-carbon and digital economy.

Saskatchewan is currently the province with the highest number of critical minerals mined in Canada. The province currently has twenty-three of the thirty-four critical minerals on the Canadian Critical Minerals List, and authorities aim to make it a global leading producer of critical minerals (Natural Resources Canada; First Nations lay claim to critical minerals and resources). Natural Resources Canada classifies critical minerals as the foundation of modern technology, guiding investments and strengthening supply chains and that minerals are considered critical because of their irreplaceability, scarcity, and limitation to regions. This classification aims to position Canada as a sustainable and strategic partner in global supply chains.

Critical minerals in Canada are classified based on their contributions to priority value chains such as advanced manufacturing, defense applications, and advanced materials, outlined in the framework of the Critical Minerals Strategy. Priority is placed on high-value-added metals that enhance clean technologies, batteries for zero-emission vehicles, and renewable energy generation (Critical Minerals Strategy, Canada).

Canada focuses on securing an internal supply of critical minerals to support local industries and the clean energy transition and to limit reliance on external supplies (Government of Canada, 2022). As of June 2024, Natural Resources Canada identified thirty-four minerals deemed essential for economic security, digital economy, defense technology, climate change, global allies, clean energy technology and green transition (Natural Resources Canada, 2024). Six of the thirty-four minerals are currently prioritized based on their roles in renewable energy production, green technologies, strategic production, and general economic growth (Natural Resources Canada, 2022). Those six minerals include lithium, graphite, nickel, cobalt, copper and rare earth minerals.

The recent tariff conflict between Canada and the United States has influenced some Canadian provinces to explore alternative markets for their mineral resources as the country aims to keep critical minerals within Canada until they reach a final product for export. Ontario and Alberta signed Memorandums of Understanding to build infrastructure, such as rail lines, pipelines, aimed at promoting and facilitating interprovincial economic relationships through critical minerals supply chains. The agreement also aims to facilitate the regional processing and exportation of minerals through ports. The interprovincial trade partnership intends to limit Canadian reliance on the United States trade partnership and to strengthen Canadian industries.

The Memorandums also aim to diversify trade by developing infrastructure that will strengthen Canadian commerce outside the United States. They also focus on eliminating provincial trade barriers and promoting a unified supply chain of minerals to support Canadian industries. The agreement additionally acts as a key step towards prioritizing Canadian-made products. https://news.ontario.ca/en/release/1006158/ontario-and-alberta-working-together-to-build-new-energy-and-trade-infrastructure.

Where are critical minerals found in Canada?

Natural Resources Canada argues that critical mineral mines, smelters, refineries or advanced projects are in every Canadian province and territory. The list below shows the provinces and the specific minerals available in their territories (Natural Resources Canada).

Alberta: lithium, nickel, cobalt, titanium, copper, gallium, Germanium, magnesium, Molybdenum, potash, rare earth minerals, scandium, titanium, uranium, vanadium, zinc, zirconium (Critical minerals in Alberta; Natural Resources Canada).

British Columbia: molybdenum, lead, coal, magnesium, gold, niobium, aluminum, copper, zinc, bismuth, indium, germanium, silver, metallurgical, silica, and cadmium (Critical minerals in British Columbia; Natural Resources Canada). British Columbia is the leading producer of Copper in Canada, with the stewards of the First Nations aiming to make it the largest producer of copper in the global market (BC First Nations Critical Minerals Strategy, 2024).

Manitoba: Lithium, graphite, rare earth minerals, nickel, copper, cobalt, cesium, tantalum, chromite, helium, magnesium, platinum-group elements, potash, vanadium, titanium, zinc, gold, antimony, bismuth, fluorspar, gallium, manganese, molybdenum, niobium, scandium, tellurium, tin, tungsten, uranium, silicon (Critical minerals in Manitoba; Natural Resources Canada).

New Brunswick: tungsten, molybdenum, tin, antimony, indium, gold, lead, zinc, copper, silver, cadmium, bismuth, potash, nickel (Critical minerals in New Brunswick; Natural Resources Canada).

Newfoundland and Labrador: rare earth elements, nickel, cobalt, antimony, fluorspar, manganese, iron ore, antimony, tungsten, molybdenum, uranium, vanadium, and zinc (Critical minerals in Newfoundland and Labrador***;*** Natural Resources Canada).

The Northwest Territories: rare earth elements, cobalt, bismuth, copper, lithium, gold, lead, zinc, silver, tungsten (Critical minerals in the Northwest Territories; Natural Resources Canada).

Nova Scotia: tin, copper, zinc, lithium, rare earth minerals, manganese, indium, gallium, graphite, cobalt, antimony, niobium, tantalum and tungsten (Critical minerals in Nova Scotia: Natural Resources Canada)

Nunavut: copper, nickel, cobalt, platinum group metals, zinc, lithium, manganese, graphite, rare earth minerals, uranium, silver, gold, lead, palladium (Critical minerals in Nunavut; Natural Resources Canada).

Ontario: phosphate, zinc, graphite, nickel, cobalt, indium, tellurium, selenium, platinum group elements, rare earth minerals, barite, chromite, fluorspar, magnesium, molybdenum, niobium, and tungsten (Critical minerals in Ontario; Natural Resources Canada).

Quebec: lithium, magnesium, rare earth minerals, graphite, nickel, cobalt, platinum group elements, vanadium, molybdenum, niobium, copper, scandium and aluminum, titanium, high-grade iron ore, antimony, bismuth, cadmium, cesium, gallium, indium, tantalum, and tellurium (Critical minerals in Quebec; Natural Resources Canada).

Saskatchewan: cobalt, copper, nickel, chromium, niobium, tellurium, potash, aluminum, rare earth minerals, magnesium, manganese, titanium, molybdenum, tungsten, uranium, phosphorus, lithium, tin, scandium, tantalum, fluorspar, graphite, gallium, helium, bismuth, zinc and platinum group metals (Critical minerals in Saskatchewan: Natural Resources Canada).

Yukon: copper, zinc, molybdenum, tungsten, tin, nickel and platinum group elements (Natural Resources Canada; Yukon critical minerals inventory, 2021).

The Critical Minerals Centre of Excellence places priority on six of the thirty-four critical minerals based on the role they play in the energy transition and the Canadian economic growth. They are lithium, graphite, nickel, cobalt, copper, and rare earth minerals. The Critical Minerals Centre of Excellence sets out criteria for what a critical mineral is and says that to be considered a critical mineral, the supply chain must be threatened, and there must be a possibility of the mineral being produced in Canada. It also says the material must either be essential to Canada's national or economic security, be needed to transition to a low-carbon digital economy or position Canada as a sustainable strategic partner within the global supply chain. The choice of these minerals is also based on the need to meet the global shift towards green technologies and sustainable environmental practices (The Critical Minerals Centre of Excellence).

What is the United Nations' stance on Critical Minerals?

The United Nations acknowledges the strategic relevance of critical minerals in employment, economic growth and in realizing the demand for a low–carbon and sustainable society, emphasizing the need for a clean energy transition (Ash, 2024*)*. This is evident in the December 2015 Paris Agreement, where members of the United Nations Framework Convention on Climate Change agreed to limit global warming to 1.5◦ °C, targeting 100 % zero-emission energy by 2050. (Ash, 2024; United Nations Environment Program,2024). Additionally, the United Nations Framework Convention on Climate Change (UNFCCC) estimates that investment equivalent to one hundred and twenty-five trillion dollars is required globally to achieve zero emissions by 2050 (Dou et al., 2023). In addition, the International Renewable Energy Agency projects that about 90 % of global electricity will be generated from renewable energy by 2050, providing reliable energy and improving economic conditions (IRENA, 2021). The United Nations advocates for a transparent, fair and sustainable management of mineral resources as the global demand for critical minerals increases owing to their role in the energy transition (United Nations Conference on

Trade and Development, 2023). As a key proponent of human rights, the United Nations emphasizes the impact of mining and exploring critical minerals on the environment and human rights, advocating for consideration of recycling, ethics, and proper management of materials to minimize the ecological impact of mining activities (UNEP, 2022). The organization also calls for the involvement of mining communities in mining-related decisions to assess the impact of mining and ensure sustainability and social justice. The United Nations, in collaboration with the Intergovernmental Forum on Mining, has set up specific guidelines to help countries establish sustainable mining policies, emphasizing policies that impact environmental, social, gender and Indigenous Peoples' rights (IGF, 2021). These policies align with the broader United Nations' goal of ensuring that mineral supply chains contribute to sustainable development. The SIRGE coalition on Indigenous Rights and Minerals Extraction adds that achieving a fair and just energy transition hinges on collaborating sincerely with Indigenous Peoples, recognizing them as equal partners in development, valuing their crucial role in safeguarding biodiversity, and honoring all their rights, including those outlined in the United Nations Declaration on the Rights of Indigenous Peoples (UN Secretary-General's Panel report, Sept 2024). The coalition demands enforceable commitments to fully uphold Indigenous Peoples' right to Free, Prior, and Informed Consent (FPIC), fair distribution of benefits, governance, and legal safeguards for land and environmental defenders. The coalition further emphasized that Indigenous Peoples' rights cannot be negotiable, and that decisions made today affect their future and that of their children. It is essential to secure their free and informed consent before approving any projects that impact their lands, territories, and resources.

The United Nations encourages countries to ensure the efficient exploration and management of critical minerals to avoid associated risks such as geopolitical conflicts, environmental and social problems affecting societies, health, the environment and human rights (UN panel on Critical Energy Transition Minerals, April 2024).

What are the impacts of mining for the energy transition on Indigenous territories?

As the demand for critical minerals intensifies, there is an urgent need for a detailed overview of the social impacts of mineral exploration on Indigenous Peoples' territories. It is estimated that about 68 % of critical mineral extraction projects globally are either situated on or near Indigenous territories (Ash, 2024). Natural Resources Canada also notes that about six hundred Indigenous communities live within one hundred kilometres of a major mining project. This is evidence that Indigenous People experience the impacts of mining more than any other group. Despite the advocacy for a Just Transition to clean energy, there are concerns that the impacts of the transition will affect vulnerable groups and communities, which could result in the emergence of green sacrifice zones, where the safety of mining communities would be sacrificed for the benefit of others (Zhou & Brown, 2024). A study by Soule et al. (2025) highlights the impact of mining on Indigenous territories in Ghana, using the lithium project at Ewoyaa as a case study. The focus of the project was on income generation and employment creation. There was little emphasis on the impact of the project on the community, though they were already facing challenges with clean water, low food production and had no health facilities. Evidence from the study shows that an average member of the Awoyaa community will not be able to afford bottled water, an indication that the majority will be exposed to health risks because of unclean water. In the long run of the project, some will be forced to relocate to cities and face challenges such as high cost of living. Dou et al. (2023) assert that, in most cases, mining communities continue to endure the consequences of mining activities even years after the end of mining projects.

According to the Aqueduct Water Risk Atlas, a minimum of 40% of water is needed annually for mining in mining communities, creating competition for water between communities, the ecosystem and industries and increasing stress for fresh water. The World Resources Institute (2024) reports that, in Chile, lithium and copper mining alone consume more than 65% local water supply, destroying water for Indigenous farming communities in communities that already face water scarcity. The report further states that in Chile and Argentina, harmful chemicals from lithium mining pollute fresh water, making it unsafe for plants, animals and communities that depend on those waters (World Resources Institute, 2024). Also, the Neskantaga community of the First Nations People in Ontario, Canada, has faced water crises for about twenty-nine years, with many people depending on boiled or bottled water (Scott, 2024). Though the situation is not caused by mining, the increasing demand for critical minerals could worsen their plight, as there are already proposals to establish mining projects in their communities, which could affect water sources such as the Attawapiskat River (Scott, 2024). Another practical example is the Kudz Ze Kayah mine in southeast Yukon, Canada, which involves an open-pit mining of zinc, copper, lead, silver, and gold on the traditional territories of the Kaska First Nations (https://kudzzekayah.com/). The Kaska First Nations opposed the project, stating that it could threaten the Finlayson caribou herd, which serves as an indicator species for the health of their regulatory systems, to extinction. Despite the First Nations' protest, the government approved the project, overlooking the environmental impact of the land on local communities. Though the mine is expected to operate for nine years, there will be lasting harm to the Kaska First Nations, including the destruction of their sacred place and the caribou habitat. The approval of the project undermines the rights of the Kaska Nations and their physical and spiritual health. Also, the lack of proper mining regulations in mining communities leads to environmental challenges such as water pollution, deforestation and land degradation (McLellan et al., 2016). Ghana is one of the African countries rich in mineral resources such as gold, bauxite, lithium and diamond, but the country is faced with rampant illegal mining activities, which have become a nationwide concern (Soule et al., 2025). Authorities have failed to control the menace, leading to constant water pollution, deforestation, and the destruction of farmlands and forest reserves.

The transition to electric vehicles is expected to be extremely mineral-intensive in the global North (Scott, 2025, p. 39). Ontario's Ring of Fire mineral belt produces critical minerals, such as nickel, cobalt and chromium, which are expected to have a significant impact on Indigenous communities, particularly around the Boreal Peatlands, which has long served as a home to the Anishinaabe and Anishini Peoples and a refuge for the caribou, lake sturgeon, and wolverines (Scott, 2025). Renewable energy is land-intensive, which can lead to environmental and social challenges such as air and water pollution, land degradation, loss of biodiversity and health risks in mining communities if projects are not managed well (World Economic Forum, May 2023). The SIRGE coalition notes that about half of mineral deposits remain on Indigenous territories, causing environmental harm and exposing natives to health risks (UN Secretary-General's Panel report, September 2024). In addition, the increase in critical minerals demand can aggravate environmental challenges such as land degradation, water pollution, air pollution, and loss of biodiversity, leading to ecological destruction on Indigenous territories (Bernauer, 2025; Dou et al., 2023; Whyte, 2020). This can disrupt aspects of Indigenous People's customs and practices, such as farming, hunting, and fishing, which are vital to their cultural heritage (Bernauer, 2025; Whyte, 2020).

What are the impacts of mining for the energy transition on Indigenous sovereignty?

Despite glaring evidence of the environmental and social impacts of mining activities on Indigenous territories, there are no legislative orders guiding mining operations to assess potential harm to Indigenous People and local communities (Ash, 2024; World Economic Forum, 2023). Research shows that assessments on mining projects focus on the prospects of the project without considering the impact of their activities on local communities (Ash, 2024). Local authorities and community leadership are often excluded from decision-making on mining projects, limiting their ability to address challenges or stop mining operations on their lands (Ash, 2024). This act not only disregards and disempowers traditional leadership, but it also creates conflicts, destroys community relationships and denies the opportunity to plan their safety and protect their rights, including the right to ownership (Ash, 2024). Zhou & Brown (2024) add that Indigenous Peoples' voices are often suppressed by Western knowledge in discussions regarding critical minerals despite their knowledge and experience on environmental sustainability, labelling it as primitive and not considered in critical minerals deliberations, undervaluing Indigenous wisdom. Sadly, Indigenous communities suffer the consequences of decisions made by mining industries when their decisions backfire. A practical scenario of this is what happened in Sweden between local authorities and the Sami Indigenous People regarding mining in their lands (Zhou & Brown, 2024). The local authorities and mining companies disregarded the decisions of the Sami People while assessing the impacts of the Kau nisvaara and Stihke mines, leading to misjudgments and wrong estimations. Unfortunately, the Sami People had to bear the consequences of the outcome, with some of them forced to relocate. Hayden (2025) also highlights tensions between the Government of Ontario and First Nations communities regarding land rights, resource development and consultations on mining projects. The government strategically passes a bill that overshadows First Nations' rights and treaty obligations. An Indigenous member of the legislature was even removed from the legislature because he spoke against the bill and the government's actions against the Indigenous People. It is obvious that the government was determined to carry out the project without the consent of the rightful landowners. Their actions not only demonstrated a disregard for the First Nations' rights but also a disrespect for Indigenous authority and sovereignty and an indication of how local authorities use state institutions to oppress Indigenous People. These experiences highlight how Western power structures and dominant societies value Indigenous Peoples and their knowledge systems. Indigenous communities continue to face marginalization, systemic and epistemic injustices, where their wisdom and authority are undervalued. They are sidelined in issues that concern their communities and forced to accept what people who have no knowledge of their communities and concerns think is good for them. State laws are made to protect the state, rather than the citizens and vulnerable communities. Indigenous Peoples are not antagonists of the energy transition. Indigenous communities also benefit from the energy transition and mining projects. They only advocate for inclusive negotiations and effective engagement and value for Indigenous wisdom, sovereignty and authority as captured in the 2024 Arctic mining report.

As the mineral demand hikes, most activities related to the production of critical minerals in Canada will take place on First Nations territories. To create a robust and effective critical minerals strategy, the governments of Canada and provincial authorities need to ensure the active involvement of First Nations in every phase of the critical minerals sector (First Nations Critical Minerals Strategy, 2024).

Scott (2022) argues that critical minerals exploration is a threat to Indigenous communities, citing the settler law as a challenge to Indigenous sovereignty and ownership rights. According to the article, Canada's constitution grants ownership of resources to provinces, rather than to the Indigenous People, who are the rightful owners of the land. Moreover, it is noted that mining activities and projects in Canada mostly take place on Indigenous communities; however, provincial authorities endorse mineral rights without seeking the views of Indigenous communities and their authorities (Papillon & Rodon, 2020). This is not only a violation of their authority but also an infringement of their legal and human rights.

Brown et al. (2024) describe the mining industry as notorious, asserting that critical mineral operations are a menace to land ownership rights and the lives of Indigenous People and their communities. Indigenous People are sometimes denied or offered temporary access to their lands due to resettlement agreements, which may not favor them, but they must accept the terms of the resettlement, raising concerns about the security of their lands (Brown et al., 2024).

What are the impacts of mining for the energy transition on Indigenous Peoples and their health? (physical, mental, emotional, spiritual)

It is argued that most projects and activities are carried out on Indigenous Peoples' lands, with most activities destroying the land and livelihoods on it (Ash, 2024). Indigenous Peoples face the challenge to protect the sanctity and sacredness of these lands which affects their physical and spiritual lives as well as their emotional needs. Indigenous People value the land as a home to their ancestors, and it is their responsibility to protect it and to preserve their spiritual health and culture. Uncontrolled mining activities destroy the land, which serves as a source of forest and water bodies that promote activities such as farming, medicine, hunting, fishing, which form part of the daily life of the Indigenous People (Ash, 2024).

Mining explorations may force Indigenous settlers to relocate, depriving them of emotional and physical attachment and relationship to their land and ancestors (Ash, 2024). Additionally, giving away ownership and sovereignty of their land and their voices being suppressed by local authorities and mining firms causes emotional and mental trauma to Indigenous People (Brown et al., 2024; Zhou & Brown, 2024). For example, in April 2025, the Trump administration proposed the Resolution Copper mine at Oak Flat, on the land of Apache Stronghold, a known religious and environmentalist group, located in the Tonto National Forest, Arizona. This action was in line with an executive order focused on enhancing domestic critical mineral development. In the president's order, the land was supposed to be handed over to the mining firm to start exploration. While the Indigenous People challenged the directive in a high court, plans were already in place for the land to be transferred to the miners. The federal court eventually ruled in favor of the State, granting permission for the land to be transferred. The Indigenous group tried an appeal in the Supreme Court, but the court declined their petition, paving the way for the land to be transferred.

Trump puts Resolution Copper Mine at Oak Flat on permit fast-track. The decision overlooked the potential impact of the project on the community. The destruction of the sacred place also violates the Indigenous Peoples' religious rights, depriving them of their spiritual health and could force them to relocate.

Dou et al. (2023) note that critical mineral extraction is closely linked to Sustainable Development Goals (SDGs) regarding health and well-being, social equity, and sustainable communities, yet the practices often undermine these goals, exposing mining communities to the unbearable challenges associated with mineral exploration. Studies show that crops grown on reclaimed mining lands contain metal deposits such as lead, mercury, copper, iron, zinc and cyanide used in mining (Anim et al., 2025). These chemicals not only reduce the nutritional value and safety of the crops, but they also pose short-term and long-term health risks to consumers. A study was conducted in Ghana using one of the most consumed crops, Cassava (Anim et al., 2025). The researchers used samples of cassava from a non-mining community and a reclaimed land from a mining community. The study revealed that cassava from non-mining lands contained lower levels of lead, iron, copper, zinc and cyanide, whereas cassava from reclaimed mining lands contained higher levels of lead, iron, copper, zinc and cyanide. The authors noted potential health risks of consuming cassava with higher levels of lead, copper, zinc and cyanide, such as symptomatic poisoning in both children and adults and neurological defects in children. The study suggests that other crops grown in reclaimed mine lands could also pose similar health risks to consumers. Miners and mining communities have a higher risk of cancer and respiratory diseases resulting from harmful chemicals, contaminated water, air and food (Brown et al., 2024). It is noted that cobalt miners have a high risk of harmful metals in their bodies because of continuous exposure, which could result in cancer and respiratory diseases (Brown et al., 2024).

There is limited or no education on the impacts of mining and the energy transition on Indigenous communities, limiting their awareness of the impact of mining and involvement in decision-making (Ash, 2024). Mining communities need to be educated on the health and environmental impacts of mineral exploration, particularly on their lands, to allow them to make firm decisions and take responsibility.

Does the energy transition require more mining than fossil fuels?

Although the transition to low-carbon technologies, such as wind turbines, solar panels, and other forms of renewable energy has increased the demand for critical mineral extraction, it is noted that the material intensity per unit of electricity generated is far less than that generated from fossil fuels (Richie, 2024). Additionally, while fossil fuels require continuous extraction of fuel to function, energy transition technologies such as solar panels and wind turbines mostly depend on a one-time installation of renewable materials, thereby reducing the demand for continuous mining (World Economic Forum, June 2024). Adding to the argument, Krane & Idel (2021) assert that the energy transition does not depend on fuel to function once established, reducing the demand for a continuous material input and eliminating geopolitical factors such as trade wars, wars, and labor strikes. Moreover, Nijnens et al. (2023) note that while fossil fuels require continuous extraction, the energy transition offers an end-of-life renewable generation, offering a possibility of reuse.

In contrast to a popular misconception that the surge in demand for critical minerals will increase mining activities, scholars such as Nijnens et al. (2023) argue that the energy transition will lead to a reduction in mining activities, stating that the amount of minerals needed for the energy transition is less than the amount of coal generated from fossil fuels. For example, research conducted in Texas, United States, notes that substituting one gigawatt of coal power with wind energy reduces mining by twenty-five million tons over twenty years, highlighting a good deal of material gain (Krane & Idel, 2021). The authors further indicate that the material demand for the energy transition is comparatively less than that of fossil fuels, citing a 3% global coal production in 2020 for critical minerals production despite the high demand. Moreover, according to the International Renewable Energy Agency, in 2022 alone, about seven trillion dollars were spent in the fossil fuel industry on subsidies. In contrast, it is estimated that about $4.5 trillion worth of investment is required annually in the renewable energy industry from now till 2030 (IRENA).

Do fossil fuels require more extraction?

Despite the urgent global demand for renewable energy, many nations and industries still rely on fossil fuels (IEA, 2021). The material and energy demand for fossil fuels is sharply different from renewable energy. Unlike renewable energy, fossil fuels are material-intensive and require many raw materials for energy production (Nijnens et al., 2023). Richie (2024) notes that fossil fuels require more materials to generate a gigawatt of power, suggesting that a surge in demand will require more extraction. According to the International Energy Agency (2020 report), about fifteen billion tons of fossil fuels are extracted annually, which is about five hundred and thirty-five times more than the mining needs of the energy transition in 2040.

The World Economic Forum (2023) reports that the extraction of fossil fuels is operated continuously, requiring more material and financial resources to be stable. The International Energy Agency (2023) contends that as renewable energy takes over the global energy market with cheaper and reliable options, fossil fuel industries will face competition, requiring them to subsidize costs. Since the extraction is expensive, it means that industries must produce more fuel to account for the subsidies, which also comes with another cost (International Renewable Energy Agency).

What is the relationship between critical minerals and our relationship with energy, materials and land?

A low-carbon energy transition will be material-intensive, as green technological developments will depend on large-scale extraction of minerals and metals to meet economic demands, particularly in the production of electric vehicles and renewable energy infrastructures such as wind turbines and solar panels (Bazilian, 2018). As a result, the demand for critical minerals is expected to surge and will continue over the coming decades as demand for renewable energy increases globally (Brown et al., 2024; L'Ebvre et al., 2020). Additionally, it is estimated that about 40% of the cost of a standard new vehicle depends on digital devices, sensors, and other electronic components, which also rely on metals and minerals (Savacool et al., 2020). A recent study indicates that material demand from 2015 to 2060 for new technologies is expected to increase by 87,000% for electric vehicle batteries, 1000% for wind power, and 3000% for solar PV power (Savacool et al., 2020). These increases buttress the argument that the energy transition will be highly material-intensive.

The push for a low-carbon society would not be possible without an adequate supply of raw materials to produce clean technologies (Ali et al., 2017). The development of renewable energy sources and other high-technology applications will require a new infrastructure that will consume a different mix of minerals. According to the British Columbia First Nations Critical Minerals Strategy (2024), the construction of renewable energy requires a high amount of critical minerals, and that mining and green technologies complement each other. While green energy transition technologies need mining, mining needs transition technologies to become green and sustainable. Furthermore, Rosewarne (2024) posits that the green energy project is land-intensive, stating that the establishment of utility-sized and mega-sized solar and wind farms requires a large amount of land, which would create socio-ecological problems in affected communities. The World Trade Organization further notes that transitioning from a fossil fuel-intensive economy to a clean energy economy requires a shift to a material-intensive energy system. The organization further states that renewable technologies such as wind turbines, solar panels, and batteries, which drive low-carbon energy systems, require more mineral inputs than their fossil fuel products. For example, it is projected that an electric vehicle requires six times the mineral input of a regular car, and an onshore wind turbine will require nine times more mineral resources than a gas power plant of equivalent capacity (International Renewable Energy Agency).

The urgency of the energy transition can result in fast-tracking approvals of mining projects, sidelining rigorous planning and engagement, and reducing accountability for social and environmental impacts (Hine et al. 2023). In most cases, governments undermine the social and environmental impact of extraction and refining, especially on Indigenous territories (Hine et al., 2023). The social burdens and biases of critical mineral exploration are disproportionately placed on Indigenous and marginalized communities (Ash, 2024). The extraction and processing of critical minerals come with severe environmental consequences, such as deforestation, land degradation, destruction of biodiversity, air pollution and contamination of freshwater that primarily affect Indigenous and vulnerable communities (Brooks et al., 2024; Dunlap & Marin, 2022).

The high demand for critical minerals can also result in power abuses, especially against Indigenous rights and sovereignty, as authorities will hide behind the shadow of the transition to expedite mining projects at the expense of the well-being of local communities. The transition can also ignite or escalate geopolitical tensions as countries aim to secure supply chains of key minerals (Pineda, 2022). As the trade war looms and is expected to intensify, countries are actively seeking to diversify their supplies, engage in friendshoring and onshore mining operations to enhance economic growth and stability (Hine et al. 2023; Natural Resources Canada).

The energy transition is a complex web. While we seek a green and low-carbon society, we create other problems like those we are trying to eliminate. Critical minerals are necessary for a green economy, but their extraction creates other problems for society. While the transition is less expensive, establishing it is expensive, as it requires more materials to establish. Green technologies, such as solar panels and wind turbines, might not be expensive for energy production, but they depend on critical minerals that require intensive mining. Indigenous communities endure the impact of both scenarios. While they face the challenges of mining, they also face the challenges of green technology installations, as both require large land sizes. The future might look green, but it could be an 'entangled green' because other people's green will be sacrificed for the ultimate green.

What are the key minerals used for the energy transition?

Although countries identify, classify, and value critical minerals to align with their strategic and economic goals (Kondrashov, 2023), certain minerals are globally considered critical due to their role in the energy transition and the global demand for a low-carbon economy. These minerals include lithium, graphite, nickel, cobalt, copper and rare earth minerals. For example, Solar panels need a combination of minerals such as rare earth minerals, cadmium, and graphite (Nijnens et al., 2023; wang et al., 2023; Zhou & Brown, 2024).

Below is a chart containing the six critical minerals, their uses, and the environmental impacts of their exploration.

Name of Critical Mineral	Uses	Impact on the environment (*Refer to the impacts of critical minerals section for references*)
Lithium Lithium is a chemical element with a purity of 99.5%. (reference). It is often referred to as a green metal and the new gasoline because of its glowing qualities (Hine et al., 2023). The IEA projects a 4,200% increase in lithium demand by 2040, rising from 101 kt in 2021 to over 1326 kt in 2040 (IEA, 2024). Australia, Chile and Argentina are the leading producers of lithium with about 89% in total production (Bonnet, 2025; Siljković et al., 2017) Lithium is the most in-demand mineral out of the six critical minerals (Brooks et al., 2024, p. 3, IEA, 2024)	• Lithium is used in lithium-ion and lithium-polymer rechargeable batteries for electronic and portable devices such as drones and to power electric vehicles and electric bikes. • Lithium is used to produce batteries for grid-scale energy storage systems to help reduce reliance on fossil fuels. • Lithium batteries are used to power aerospace devices such as drones and power satellites because of their high energy density and lightweight. • Lithium batteries are used to power medical critical devices such as infusion pumps, defibrillators, and pacemakers because of their durability and reliability. • Lithium compounds are used in aircraft construction because of their lightweight and thermal properties	• Lithium mining consumes about 65% of water, leading to water shortages in local communities. • Open pit mining and land transformation destroy the soil landscape, resulting in soil erosion and the destruction of wildlife habitat, biodiversity and ecosystems. • Poor management of chemicals such as hydrochloric acid and sodium carbonate can lead to water pollution, endangering human life and biodiversity. • Dust resulting from digging and blasting causes air pollution, causing respiratory concerns for local communities. • Improper management of waste from lithium mining can be harmful to the environment.

Cobalt Cobalt is a strong, durable metal resistant to corrosion with a lustrous silver-grey appearance and is mostly used in batteries for electric vehicles (Natural Resources Canada). The Democratic Republic of Congo is the leading producer of cobalt, with about 73% of the global production (Natural Resources Canada) Cobalt is mined as a by-product of copper and nickel (CODA Minerals).	• Cobalt promotes stability, energy density and safety in rechargeable lithium-ion batteries. • Cobalt is used to produce permanent magnets, such as samarium-cobalt, used in wind turbines. • Used for alloys in gas turbines, jet engines, because of their strength, oxidation and heat resistance. • Cobalt is used in medical and healthcare for cancer treatment, dental crowns, prosthetics, medical implants, and sterilizing medical equipment. • Cobalt compounds are used as catalysts to increase chemical reactions and reduce waste pollution in petroleum refining, plastic and fertilizer production. .	• Toxic waste substances such as lead and arsenic pollute sources of water, destroying aquatic life and the ecosystem and making water unsafe for human use. • Dust from cobalt mining reduces air quality, causing respiratory and other health complications for miners and residents. • Cobalt mining demands significant land clearing, resulting in deforestation. • Chemical concentrations in soil destroy soil organisms that promote soil fertility and crop growth, threatening food security for local communities.

Nickel Nickel is described as a versatile, strong metal resistant to corrosion and can endure harsh weather conditions (Natural Resources Canada). As of 2023, Indonesia was the leading producer of Nickel with about 42 % of the global nickel reserves (Natural Resources Canada). Nickel is said to be the fifth most abundant metal on earth and one of the most used metals, used in more than 300,000 products (Thought.Co).	• The cathodes in nickel promote battery energy density, performance and lifespan. • Its strength and capacity to endure harsh weather make cobalt suitable for renewable energy such as solar panels, wind turbines, and other energy storage systems. • Nickel is added to stainless steel production to enhance corrosion resistance, strength and durability. • Nickel is used for medical implants because of its resistance to corrosion and biocompatibility. • Nickel is used to make alloys used in power generation, aerospace, and defense industries to maintain strength and oxidation resistance.	• Harmful substances such as nitrogen oxides and sulphur dioxide emitted from nickel extraction cause air pollution and global warming. • Mining waste can lead to soil pollution and environmental health issues if not properly managed. • Wastewater from nickel mining contains chemicals like acids and metals that pollute water sources, causing harm to aquatic life and residents. • Nickel mining is seen as a threat to climate because of the destruction of forests, wildlife habitat and ecosystems.

Copper Copper is a soft, durable, and malleable metal resistant to corrosion and noted for its high conductive and thermal properties (Natural Resources Canada). Copper is a key mineral in the energy transition as a major element used in electric vehicles and energy storage production (Natural Resources Canada). Chile is the global leading producer of copper, while British Columbia is the largest producer of copper in Canada based on 2023 statistics (Natural Resources Canada).	• Copper's resistance to corrosion, conductivity and thermal strength make it suitable for industrial machinery and equipment such as condensers, wind turbines, and in renewable energy and clean technologies such as electrical grids, solar panels, and wind turbines. • Copper is an essential element in transportation and electric vehicle industries because of its strength and resistance to corrosion. • Copper is used in electronics and electrification, such as in electrical wiring, connectors and energy storage, because of its conductivity. • The antimicrobial properties of copper make it an essential element in healthcare in decreasing the spread of infections, and in medical equipment such as MRI machines, surgical robots and implants.	• Local communities face health concerns such as cancer, respiratory diseases, and children's healthy development because of exposure to harmful chemicals. • Acid mine drainage in copper extraction causes water pollution because of metals such as lead and mercury exposed to water sources. • Mining and processing copper emits pollutants such as dust, sulphur dioxide and particulate matter that cause air pollution, causing harm to miners and nearby communities. • Waste from mining reduces soil quality, which affects agricultural production and can eventually lead to soil erosion. • Copper mining destroys habitats and increases wildlife vulnerability.

Graphite Graphite is a non-metallic mineral that can conduct heat and electricity (Natural Resources Canada). It is the strongest and stiffest among all materials and has high resistance to corrosion (Focus Graphite). The demand for graphite is expected to increase as it is an essential element in electric vehicle batteries (Natural Resources Canada). China is the largest producer of graphite, with 77% of the overall global production, while Canada is 11th with 0.3% of the total production (Natural Resources Canada).	• Graphite is used in Lithium-ion batteries as an anode material. • Lubricants for industrial applications such as automotive, manufacturing and machinery • They are used as catalysts and in industrial applications such as automotive, plastics, and synthetic fibres to increase efficiency and reduce emissions. • Aerospace applications such as rocket nozzles, bearings and valves • Used as a neutron moderator in nuclear reactors, helping to stabilize nuclear reactions.	• Dust emitted from mini-g activities pollutes the air in local communities, causing respiratory diseases. • Harmful chemicals from mining deposited on water sources reduce water and make it unsafe for human and animal consumption. • Graphite mining damages large areas of land, ecosystems, and biodiversity, and leads to soil erosion. • The high reliance on energy leads to greenhouse gas emissions, which can result in global warming.
Rare earth minerals Rare earth minerals are a group of 17 metallic elements with similarities in their chemical composition and related properties, subdivided into Heavy Rare Earth Elements (HREEs) and Light Rare Earth Elements (LREEs) (Wall, 2013). HREEs have higher	• Rare earth minerals are used in clean and renewable energy, such as wind turbines, electric vehicles, and solar panels. • They are used in permanent magnets in renewable energy, such as solar panels and wind turbines. • They are used for aerospace and defense technologies such as night	• The refinement of rare earth minerals releases airborne pollutants such as sulphur dioxide and heavy metals. These contribute to smog formation and respiratory health issues among local communities. • Mining operations often require extensive land

atomic weights and are less common. This means that they are potentially more valuable in supply chains, although having a smaller range of uses relative to some of the LREEs (Brown et al., 2024). Rare earth minerals are mostly used in permanent magnets production, equivalent to 44% of their usage (Natural Resources Canada). China is the leading global producer (70%) and refiner (87) of rare earth minerals, while Canada has some of the biggest rare-earth resources and reserves, amounting to about 15.2 million tons as of 2023.	vision goggles, satellite drones and jet engines. • Rare earth minerals are essential in health care technologies such as X-ray and MRI machines. • Rare earth minerals enhance performance and miniaturization in electronic devices such as computers, smartphones and digital cameras.	clearing, leading to significant deforestation and loss of biodiversity. This not only disrupts local ecosystems but also contributes to climate change by reducing the number of trees capable of absorbing carbon dioxide. • The extraction of REMs generates large amounts of solid and liquid waste, including radioactive materials like thorium and uranium, leading to severe environmental hazards, increased health risks in local populations. • Soil degradation

Conclusion and personal view

Critical minerals play an indispensable role in global economies, modern and green technologies toward achieving a global low-carbon energy transition and a net-zero emissions target. They are also essential in advancing industrial and manufacturing sectors such as energy, healthcare, high-tech, and defense technologies. Though every country has its unique definition and valuation of critical minerals, they all target common goals: economic growth and security, green technologies, a low-carbon society, environmental sustainability and meeting modern standards of living. Research and current global development indicate that the demand for minerals such as lithium, cobalt, nickel, copper, graphite, and rare earth minerals will increase significantly in the coming years as they will be the key drivers of the energy transition. The rising demand for modern technologies such as electric vehicles, solar panels and wind turbines will result in a global expansion of mining operations, the critical minerals market and investments.

Data reveals that the energy transition comes at a high cost, particularly on Indigenous People and communities that face unjust consequences. Most critical mineral exploration projects globally are located on or near Indigenous Peoples' lands. These communities, which often maintain deep spiritual, cultural, and customary ties to their land for livelihoods such as hunting, fishing, and agriculture, bear the immediate and long-term impacts of mining activities and projects. The extraction and processing of critical minerals, though essential for a low-carbon future, are associated with unbearable harm. Mining processes are highly water-intensive, threatening local water stability and ecosystems in areas that are already facing water stress. There are also concerns about air pollution, biodiversity loss, and general environmental destruction. Mining activities are linked to human rights abuses, forced displacement, and social tensions. The high demand for critical minerals could result in fast trucking of mining projects, which will increase the persistent challenges Indigenous People face in protecting their lands, rights, sovereignty and ownership rights. Governmental authorities violate and undervalue Indigenous knowledge and experiences while making decisions on mining projects on Indigenous territories. The energy transition and pursuit of a low-carbon economy must be 'Just', honoring all parties and not ignoring the social impacts and inequities placed on Indigenous People and their communities. Indigenous communities must be involved in decision making to assess the benefits and impacts of mining on their territories. The demand for critical minerals must not only be narrowed to their importance, but there must be a thorough impact assessment and consideration of potential harm. The energy transition will bring disparities, while others enjoy the benefits, some will endure the impact; hence, governments must ensure that the transition does not supersede the well-being of mining communities.

Research on critical minerals highlights that achieving global climate goals necessitates a critical re-evaluation of current extractive models. A truly "just transition" must address historical injustices, prioritize the rights and knowledge of Indigenous Peoples, and ensure that the benefits and burdens of the energy transition are shared equally, rather than creating new "green sacrifice zones” and repeating mistakes of the fossil fuel era. As countries continue to invest in the mining industries to counter the increasing demands of new technologies, they must also consider how to sustain them through recycling to limit material dependence.

The transition is necessary; however, its impact must not be underestimated. Critical mineral exploration is material-intensive, which could create new environmental problems. The risks and burdens of the energy transition and climate change solutions should not be imposed on Indigenous and marginalized communities.

It has been an enriching experience working on this project. I have been deeply enlightened on the current and future role of critical minerals towards achieving a low-carbon society. This project has also shaped my research skills and focus on Indigenous education, highlighting how Western structures and knowledge continue to marginalize and suppress Indigenous sovereignty and wisdom, and I look forward to exploring further in these areas. I appreciate the immense support of the entire Sacred Earth community, particularly Serena Mendizabal, Erin Konsmo, Farron Rickerby-Nishi and Melina Laboucan-Massimo and look forward to another opportunity to collaborate and co-create knowledge as we have a collective responsibility in creating awareness on climate change and addressing systemic and epistemic injustices facing Indigenous People in Canada and beyond.

References:

Ali, S. H., Giurco, D., Arndt, N., Nickless, E., Brown, G., Demetriades, A., Durrheim, R., Enriquez, M. A., Kinnaird, J., Littleboy, A., Meinert, L. D., Oberhänsli, R., Salem, J., Schodde, R., Schneider, G., Vidal, O., & Yakovleva, N. (2017). Mineral supply for sustainable development requires resource governance. *Nature (London)*, *543*(7645), 367–372. https://doi.org/10.1038/nature21359

Anim, S. O., Akyereko, Y. G., Adu, M., Odoom, W., Yeboah, G. B., & Wireko-Manu, F. D. (2025). Quality and Safety of Cassava Roots Produced from Reclaimed and Non-Mine Sites. Next Research, 100364.

Ash, J. (2024). Social impacts of critical mineral exploration on Indigenous peoples' lands: A case study from Solomon Islands. The Extractive Industries and Society, 17, Article 101439. https://doi.org/10.1016/j.exis.2024.101439

ARTIC mining report (2024) https://arcticeconomiccouncil.com/reports/arctic-mining-report-2024/

Aqueduct Water Risk Atlas https://atlas.co/climate-tools/aqueduct-water-risk-atlas/

Bazilian, M. D. (2018). The mineral foundation of the energy transition. *The Extractive Industries and Society*, *5*(1), 93–97. https://doi.org/10.1016/j.exis.2017.12.002

Beiser, V. (2025). [Rev. of *Power Metal: The Race for the Resources That Will Shape the Future*]. *Natural Resources & Environment*, *39*(4), 61–62.

Bernauer, W. (2025). Energy transitions at remote mines: The implications of transitioning to low-carbon electricity generation for Indigenous rights in northern Canada. *The Extractive Industries and Society*, *23*, Article 101636. https://doi.org/10.1016/j.exis.2025.101636

Bhamra, R., Small, A., Hicks, C., & Pilch, O. (2025). Impact pathways: geopolitics, risk and ethics in critical minerals supply chains. *International Journal of Operations & Production Management*, *45*(5), 985–994. https://doi.org/10.1108/IJOPM-03-2024-0228

Benchmark Mining Intelligence (2022) https://www.autoevolution.com/news/benchmark-mineral-intelligence-calculated-how-many-more-mines-we-ll-need-for-evs-359-198133.html

Bonnet, T. (2025). Foreign direct investments and energy transition critical minerals. *Resources Policy*, *105*, Article 105551. https://doi.org/10.1016/j.resourpol.2025.105551

Brooks, S. M., Eussler, S. L., & Voeten, E. (2024). Green Transition versus the Environment?: The Politics of Mining for Critical Minerals.

Brown, D., Zhou, R., & Sadan, M. (2024). Critical minerals and rare earth elements in a planetary just transition: an interdisciplinary perspective. *The Extractive Industries and Society*, *19*, 101510. https://doi.org/10.1016/j.exis.2024.101510

Climate Forward (FWD) Canada (2025) https://www.canada.ca/en/environment-climate-change/news/2025/01/environment-and-climate-change-canadas-climate-forecasting-system-highlights-concerning-global-warming-trends.html

Critical Minerals Centre of Excellence https://mineconnect.com/article/critical-minerals-centre-of-excellence-cmce-funding-opportunities/

Critical Minerals Strategy Annual Report, 2024 https://www.documentcloud.org/documents/25499554-2024-11-a-2024-00415-natural-resources-canada/

Critical Minerals Strategy, Canada https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html

D'Orazio, P. (2024). Assessing the fiscal implications of changes in critical minerals' demand in the low-carbon energy transition. *Applied Energy*, *376*, Article 124197. https://doi.org/10.1016/j.apenergy.2024.124197

Dou, S., Xu, D., Zhu, Y., & Keenan, R. (2023). Critical mineral sustainable supply: Challenges and governance. *Futures: The Journal of Policy, Planning and Futures Studies*, *146*, Article 103101. https://doi.org/10.1016/j.futures.2023.103101

Dunlap, A., & Marin, D. (2022). Comparing coal and 'transition materials'? Overlooking complexity, flattening reality and ignoring capitalism. *Energy Research & Social Science*, *89*, Article 102531. https://doi.org/10.1016/j.erss.2022.102531

First Nations Critical Minerals Strategy (2024) https://fnemc.ca/wp-content/uploads/2024/03/FNEMC_critical_minerals_Report_digital_FNL-March2024.pdf

Glowing WLG (2025) https://gowlingwlg.com/en-ca/insights-resources/articles/2025/observations-from-gowling-wlgs-2025-energy-outlook

Government of Canada (2022) https://www.canada.ca/en/department-finance/news/2022/04/government-of-canada-releases-budget-2022.html

Hammond, D. R., & Brady, T. F. (2022). Critical minerals for green energy transition: A United States perspective. *International Journal of Mining, Reclamation and Environment*, *36*(9), 624–641. https://doi.org/10.1080/17480930.2022.2124788

Hayes, S. M., & McCullough, E. A. (2018). Critical minerals: A review of elemental trends in comprehensive criticality studies. *Resources Policy*, *59*, 192–199. https://doi.org/10.1016/j.resourpol.2018.06.015

Hine, A., Gibson, C., & Mayes, R. (2023). Critical minerals: Rethinking extractivism? *Australian Geographer*, *54*(3), 233–250. https://doi.org/10.1080/00049182.2023.2210733

Hund, K., La Porta, D., Fabregas, T. P., Laing, T., & Drexhage, J. (2023). *Minerals for Climate Action*. Washington, DC: World Bank. https://doi.org/10.1596/40002

International Energy Agency (2021). *The Role of Critical Minerals in Clean Energy Transitions*. International Energy Agency. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

International Energy Agency (2020) https://www.iea.org/reports/renewables-2020

International Energy Agency (2021) https://www.irena.org/publications/2021/aug/renewable-energy-statistics-2021

International Energy Agency(2022) https://www.iea.org/reports/renewable-energy-market-update-may-2022

IGF. (2021). Guidance for Governments*: Environmental and Social Impact Assessments. Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development. Retrieved from https://www.igfmining.org*

Intelligence, B. M. (2022). Benchmark Historical Lithium Price Data.

Intergovernmental Forum on Mining https://www.iisd.org/projects/intergovernmental-forum-mining-minerals-metals-and-sustainable-development-igf

International Journal of Environmental Science and Technology https://www.environmental-expert.com/magazines/international-journal-of-environmental-science-and-technology-3752

International Renewable Energy Agency (2021) https://www.un.org/Depts/los/general_assembly/contributions_2021/IRENA.pdf

International Resource Panel (2019) https://www.resourcepanel.org/news-events/international-resource-panel-2019-highlights

International Union of Pure and Applied Chemistry (2005) https://www.degruyterbrill.com/document/doi/10.1515/ci.2005.27.6.25/html

King, Hayden. "The Elbows are Up: Ontario's 'Special Economic Zones' and Indigenous Rights," *Yellowhead Institute*. 05 June 2025. https://yellowheadinstitute.org/2025/06/05/the-elbows-are-up-ontarios-special-economic-zones-and-indigenous-rights/

Kondrsashov S. (2023) Critical Minerals vs. Rare Earth Minerals. A strategic Distinction. TELF AG Insights

Krane, J., & Idel, R. (2021). More transitions, less risk: How renewable energy reduces risks from mining, trade and political dependence. *Energy Research & Social Science*, *82*, Article 102311. https://doi.org/10.1016/j.erss.2021.102311

Kudz Ze Kayah mine, Ontario https://kudzzekayah.com/

Laboucan-Massimo, Melina, Farron Rickerby-Nishi, Nick Demeris, Shahed Shafazand. *Just Transition Guide: Indigenous-led Pathways Toward Equitable Climate Solutions and Resiliency in the Climate Crisis*. (Victoria, BC: Sacred Earth Solar, Indigenous Climate Action, Power to the People, David Suzuki Foundation, 2023), https://static1.squarespace.com/static/5c9860bf77b9034bc5e70122/t/6555222edcea4d681ccf0454/1700078320040/Just+Transition+Guide.pdf

McCullough, E. A. (2018). The Critical Question: Can Mining Permit Exactions Help Procure Critical Minerals Required for Manufacturing Defense Technologies? *Nat'l Sec. LJ*, *6*, 210.

McLellan, B., Yamasue, E., Tezuka, T., Corder, G., Golev, A., & Giurco, D. (2016). Critical Minerals and Energy–Impacts and Limitations of Moving to Unconventional Resources. *Resources (Basel)*, *5*(2), 19. https://doi.org/10.3390/resources5020019

Mulvaney, D. (2019). *Solar power: Innovation, sustainability, and environmental justice*. University of California Press.

Nassar, N. T., Graedel, T. E., & Harper, E. M. (2015). By-product metals are technologically essential but have problematic supply. *Science Advances*, *1*(3), e1400180. https://doi.org/10.1126/sciadv.1400180

Natural Resources Canada (2021) https://natural-resources.canada.ca/corporate/planning-reporting/reports-2021

Nijnens, J., Behrens, P., Kraan, O., Sprecher, B., & Kleijn, R. (2023). Energy transition will require substantially less mining than the current fossil system. *Joule*, *7*(11), 2408–2413. https://doi.org/10.1016/j.joule.2023.10.005

Papillon, M., & Rodon, T. (2020). The Transformative Potential of Indigenous-Driven Approaches to Implementing Free, Prior and Informed Consent: Lessons from Two Canadian Cases. *International Journal on Minority and Group Rights*, *27*(2), 314–335. https://doi.org/10.1163/15718115-02702009

Pineda, M. G. From Fossils to Minerals: The Hidden Challenges of the Energy Transition.

Raju, R. D. (2020). Critical minerals: their nature, occurrence, recovery and uses. *Current Science (Bangalore)*, *119*(6), 919–925. https://doi.org/10.18520/cs/v119/i6/919-925

Reich, M., & Simon, A. C. (2024). Critical minerals. *Annual Review of Earth and Planetary Sciences*, *53*.

Ritchie, H. (2024). Low-carbon technologies need far less mining than fossil fuels. *Our World in Data*.

Rosewarne, S. (2024). Competing claims on land in the solar age: Valorizing capital or Country in Australia? *Energy Research & Social Science*, *112*, Article 103527. https://doi.org/10.1016/j.erss.2024.103527

Sadeghi, A., Kermani Alghorayshi, S. T., Shamsi, M., & Mirjani, F. (2023). Multi-criteria evaluation of the extraction methods of rare earth elements from aqueous streams. *International Journal of Environmental Science and Technology (Tehran)*, *20*(9), 9707–9716. https://doi.org/10.1007/s13762-023-05081-7

Scott, D. N. (2024). How the settler state continues to dispossess: Infrastructural (dis) entitlement on the critical minerals' frontier. *Journal of Law & Political Economy (forthcoming), Osgoode Legal Studies Research Paper*, (4973404).

Scott, D. N. (2025). Infrastructural (Dis)Entitlement: Tactics of Dispossession on the Critical Minerals Frontier. *Journal of Law and Political Economy*, *5*(1).

SIRGE coalition on Indigenous Rights and Minerals Extraction https://www.culturalsurvival.org/news/sirge-coalition-statement-critical-raw-materials-act#

Soule et al. (2025) *Can Critical Mineral Deals Benefit Local Communities*? Insights From Ghana's Lithium Project https://carnegieendowment.org/research/2025/07/can-critical-mineral-deals-benefit-local-communities-insights-from-ghanas-lithium-project?lang=en

Sovacool, B., Hook, A., Martiskainen, M., Brock, A., & Turnheim, B. (2020). The Decarbonization Divide: Contextualizing Landscapes of Low-Carbon Exploitation and Toxicity in Africa. *Global Environmental Change*, *60*. https://doi.org/10.1016/j.gloenvcha.2019.102028

Stephenson, A. (2023). Indigenous communities leading Canada's clean energy boom. In *The Canadian Press*. Canadian Press Enterprises Inc.

Suli, L. M., Ibrahim, W. H. W., Aziz, B. A., Deraman, M. R., & Ismail, N. A. (2017). A Review of Rare Earth Mineral Processing Technology. *Chemical Engineering Research Bulletin*, *19*, 20. https://doi.org/10.3329/cerb.v19i0.33773

Sustainable Development Goals (SDGs) https://unric.org/en/united-nations-sustainable-development-goals/

TD Economics Forecast https://economics.td.com/Forecasts

UNCTAD. (2023). The Race for Critical Minerals*: Ensuring Sustainable and Inclusive Growth. Retrieved from https://unctad.org*

UNEP. (2022). *Sustainability and Circularity in the Mineral Value Chain. Retrieved from https://www.unep.org*.

United Nations Conference on Trade and Development, 2023https://unctad.org/publication/trade-and-development-report-2023

United Nations Environment Program (2024) https://www.unep.org/resources/annual-report-2024

United Nations Environmental Program (2022) https://www.unep.org/annualreport/2022/

United Nations Framework Convention on Climate Change https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change

UN panel on Critical Energy Transition Minerals (2024) https://www.un.org/en/climatechange/critical-mineralsUnited States Energy Act (2020)

UN Secretary-General's Panel report 2024 https://brasil.un.org/sites/default/files/2024-09/report_sg_panel_on_critical_energy_transition_minerals_11_sept_2024_0.pdf

United States Geological Survey ***https://stanislavkondrashov.ch/stanislav-kondrashov-telf-ag-rare-earths-vs-critical-minerals-whats-the-differenc***

Vidal, O., Goffé, B., & Arndt, N. (2013). Metals for a low-carbon society. *Nature Geoscience*, *6*(11), 894–896. https://doi.org/10.1038/ngeo1993

Wang, B., Wang, L., Zhong, S., Xiang, N., & Qu, Q. (2023). Assessing the supply risk of geopolitics on critical minerals for energy storage technology in China. *Frontiers in Energy Research*, *10*. https://doi.org/10.3389/fenrg.2022.1032000

Weng, Z., Haque, N., Mudd, G. M., & Jowitt, S. M. (2016). Assessing the energy requirements and global warming potential of the production of rare earth elements. *Journal of Cleaner Production*, *139*, 1282–1297. https://doi.org/10.1016/j.jclepro.2016.08.132

Whyte, D. (2020). Conclusion: kill the corporation before it kills us. In *Ecocide* (p. 146). Manchester University Press. https://doi.org/10.7765/9781526151063.00009

World Economic Forum (June 2024) https://www.weforum.org/meetings/

World Economic Forum (May 2023)https://www.weforum.org/meetings/world-economic-forum-annual-meeting-2023/

Yukon Critical Minerals Inventory (2021) https://emrlibrary.gov.yk.ca/ygs/MR/MR_23.pdf

World Resources Institute (2024) https://www.wri.org/

World Trade Organization https://www.investopedia.com/investing/what-is-the-world-trade-organization/

Zepf, V. (2013). Rare Earth Elements: What and Where They Are. In *Rare Earth Elements* (pp. 11–39). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-35458-8_2

Zhou, R. (Kevin), & Brown, D. (2024). Epistemic justice and critical minerals–Towards a planetary just transition. *The Extractive Industries and Society*, *18*, Article 101463. https://doi.org/10.1016/j.exis.2024.101463