# CRITICAL CONNECTIONS

Columbite

**CANADA** DEVELOPED A LIST OF 34 ROCKS, MINERALS AND METALS deemed critical to developing a low-carbon economy, maintaining domestic industry and security, and providing exports to our global partners. Called "critical minerals" these minerals and metals are, or can be, produced in Canada. They are necessary for:

- Renewable Energy Technologies
- Manufacturing
- Aerospace and Defence
- Information and Communications Technology
- Agriculture
- Health and Life Science Applications
- Infrastructure

## Mining Makes It Happen!

# MADE IN CANADA

## TAKE TO THE SKIES

BEFORE AN AIRCRAFT TAKES TO THE SKIES, EXPERTISE GOES INTO ITS DESIGN, CONSTRUCTION, AND OPERATING AND SUPPORT SYSTEMS

According to the Aerospace Industries Association of Canada, Canadian companies' cutting-edge innovation and technology have that covered.

Critical minerals are essential to the aerospace industry, going into the wide range of products made in Canada, including regional, business, and firefighting aircraft; helicopters; and satellites.

Also produced are numerous aircraft parts, including engines, navigation systems, specialty alloys, landing gear, air traffic control systems and equipment, computer equipment and software, defence systems, simulation and modelling technologies, and more.

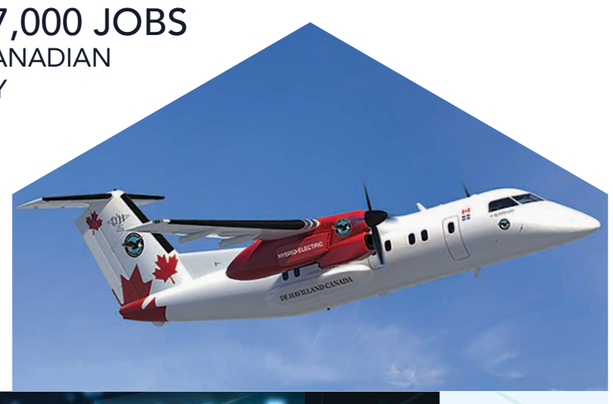
*Aluminum, Antimony, Chromium, Cobalt, Copper, Graphite, Gallium, Germanium, Indium, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Platinum Group Metals, Scandium, Tantalum, Tin, Titanium, Tungsten, Vanadium, Zinc*

Canada Arm 2
© Canadian Space Agency, Credit: NASA

In 2020, the Canadian Aerospace Industry contributed

OVER $22 BILLION
TO CANADA'S GDP

OVER 207,000 JOBS
TO THE CANADIAN ECONOMY



## A CLEAR MESSAGE

THE 21ST CENTURY HAS SEEN AN EXPLOSION OF INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) USAGE AROUND THE WORLD

Numerous critical minerals go into the equipment that transmits and receives communication and data signals. From cables to broadcast towers to networks that send radio signals, critical minerals are integral to their makeup. The electronic devices designed to receive those signals comprise numerous critical minerals that enable high-speed performance and data, along with vivid, high-resolution screens.

*Aluminum, Cesium, Cobalt, Copper, Gallium, Indium, Lithium, Magnesium, Manganese, Nickel, Platinum Group Metals, REEs, Tantalum, Tellurium, Tin, Tungsten, Zinc*

According to the Canadian Wireless Telecommunications Association, in 2020, that industry contributed

UP TO
$70.7 BILLION
TO CANADA'S GDP

SUPPORTING CLOSE TO
600,000 JOBS

## PEDAL TO THE METAL

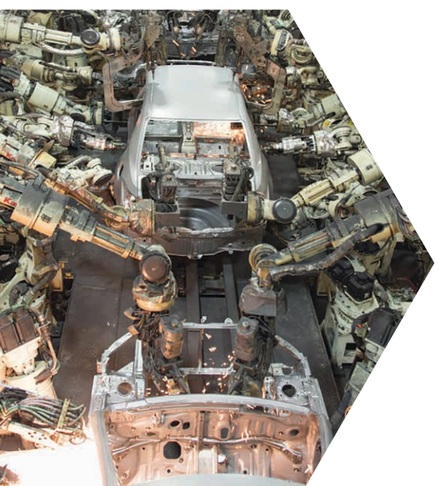
AUTOMOTIVE MANUFACTURING IS VITAL TO THE CANADIAN ECONOMY

### 1,358,657 VEHICLES

The Canadian Vehicle Manufacturers' Association stated this number of vehicles was produced in Canada in 2020, contributing over $16 billion to the GDP.

### OVER 500,000 JOBS

The auto industry is responsible for direct and indirect jobs across Canada. Vehicles are Canada's second largest export by value.



The automobile industry relies on critical minerals. Transitioning to environmentally friendly vehicles demands lighter auto bodies and parts using high-strength steel and aluminum alloys. Cleaner transportation uses electric or hybrid vehicle batteries, which require numerous critical minerals.

*Aluminum, Antimony, Chromium, Copper, Graphite, Lithium, Magnesium, Manganese, Nickel, Platinum Group Metals, REEs, Scandium, Tellurium, Tin, Vanadium, Zinc*

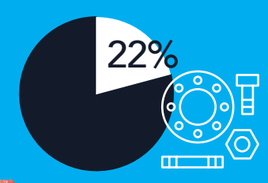
Vanadinite

## WORLD CITIZEN

CANADA'S MINERALS AND METALS SECTOR CONTRIBUTES, NOT ONLY TO THE SUCCESS OF OUR OWN ECONOMY, BUT ALSO TO ECONOMIES AROUND THE WORLD. Natural Resources Canada states that the sector supplies ores, concentrates, and semi-fabricated and fabricated metal and mineral products to over 100 countries.

OF CANADA'S TOTAL $582 BILLION OF EXPORTS IN 2021,

$127 BILLION
were metal and mineral products.



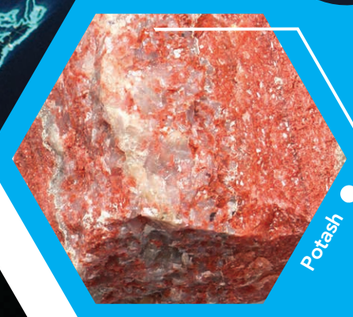

CANADA'S PRINCIPAL TRADING PARTNERS FOR MINERAL COMMODITIES IN 2021:

54% United States

10% United Kingdom

8% European Union

Other significant markets for Canadian metals and minerals include China, Japan, South Korea, Germany, Norway, and Switzerland.



Potash

### CANADIAN CRITICAL MINERALS

Canada produces and supplies domestic and global markets with a variety of critical minerals. Canada is the leading global producer of potash and ranks amongst the top five global producers for aluminum, cobalt, indium, niobium, palladium, platinum, tellurium, titanium concentrate and uranium. Canada also hosts many advanced mineral projects, including for key commodities such as rare earth elements, lithium, and vanadium.

### CANADA ALSO MANUFACTURES AND EXPORTS PRODUCTS THAT INCORPORATE CRITICAL MINERALS

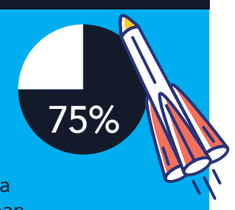
**Vehicles were Canada's second largest export by value in 2020, totalling**

$42.9 BILLION

**Exports of ICT goods in 2021 amounted to**

$9.7 BILLION

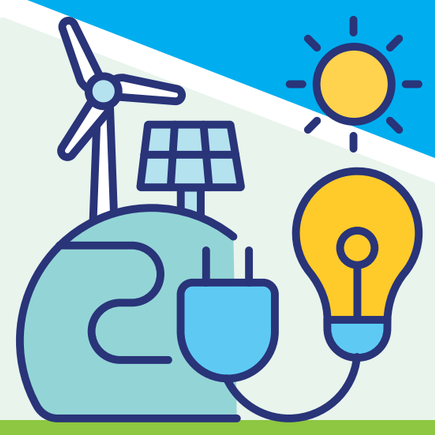
The Canadian aerospace manufacturing industry exported over 75% of Canadian aerospace products to 186 countries across 6 continents in 2020.




Relating to zero-emission goals, a 2021 ranking by Bloomberg's clean energy, new materials, and commodity research arm predicts that **Canada will be in fifth place in the global lithium-ion battery supply chain by 2026.**

2026

# CARING FOR THE PLANET



### CLIMATE CHANGE IS CONSIDERED ONE OF THE BIGGEST THREATS FACING OUR WORLD

To fight that threat, Canada, along with over 120 countries, has committed to reach net-zero GHG (Greenhouse Gas) emissions by 2050. Canada is already a world leader in the production of clean electricity, with 82% of electricity generated coming from non-GHG-emitting sources, including hydroelectricity, nuclear power, and wind and solar PV (Photovoltaic) power installations. But more power will be needed, especially as we move to cleaner transportation. The transition to a net zero future depends on the availability of critical minerals.

**HYDROELECTRIC POWER**, produced by turbine blades turned by flowing water, is reliable and cost-effective. It is the world's largest source of renewable electricity generation, and Canada was the world's fourth largest hydropower producing country in 2020. Hydropower from Canada's rivers provide nearly 60% of our electricity. *Copper, Aluminum, Zinc*

**WIND TURBINES** use the power of the wind to generate electricity. Between 2011 and 2021, global wind energy capacity nearly quadrupled. In 2021, Canada ranked ninth in the world for installed wind energy capacity. According to the Global Wind Energy Council, the world needs to install wind power three times faster over the next decade to meet our net-zero goals. *Copper, Molybdenum, Aluminum, REEs, Zinc*

**SOLAR PHOTOVOLTAIC (PV) TECHNOLOGY** converts the sun's energy to electricity. Solar PV provided 3.1% of global electricity generation in 2020, the third-largest renewable electricity technology behind hydropower and onshore wind. In 2020, Canada ranked 22nd in the world for installed solar energy capacity. *Copper, Gallium, Germanium, Indium, Molybdenum, Titanium, Platinum, Tellurium, Zinc*

**NUCLEAR ENERGY** is an important part of Canada's economy and energy mix. Nineteen Canadian CANDU reactors provide 15% of Canada's non-GHG-emitting sourced electricity in 2019. About 440 nuclear power reactors around the world provide 10% of the world's electricity; over 50 reactors are under construction. The International Atomic Energy Association expects world nuclear generating capacity to double by 2050 to meet the net-zero emissions goal. *Copper, Iron, Nickel, REEs, Uranium*

**ZERO-EMISSION VEHICLES (ZEVs)** are the way of the future. Canada aims to have ZEVs make up 100% of new cars registered by 2035. According to the International Energy Association, there were 10 million electric cars operating globally at the end of 2020, but 230 million by 2030 are needed to meet zero emission goals. Those vehicles rely entirely on batteries; lithium-ion batteries currently power most electric vehicles. *Antimony, Cobalt, Graphite, Lithium, Nickel, Magnesium, Platinum, REEs, Tantalum, Tellurium, Tin, Vanadium, Zinc*

# CRITICAL MINERALS

FROM ALUMINUM TO ZINC, CANADA IS A GLOBAL LEADER IN RESPONSIBLE AND SUSTAINABLE EXPLORATION AND MINING.

**CANADA CAN SHOW THE WORLD HOW IT'S DONE!**

## CRITICALLY CANADIAN

Mined / Processed / Potential Deposits

Bauxite

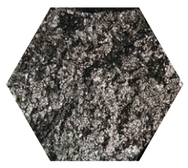
### Aluminum (Al) BC, QC

A lightweight, silvery metal refined from imported bauxite, aluminum is durable and resists corrosion. Easily shaped, cast, and machined, it is used extensively in the automotive and aircraft industry, as well as in construction, electronics, and packaging.

Stibnite

### Antimony (Sb) NL, NB

A lustrous, grey metalloid sourced mainly from the minerals stibnite and jamesonite, antimony is widely used as a flame retardant. It is an important alloy metal in lead-acid and lithium-ion batteries, multiple military applications, and tungsten steel. It goes into semiconductors, circuit boards, electric switches, fluorescent lighting, and high-quality clear glass.



Bismuthinite

### Bismuth (Bi) BC, NT

A crystalline, white metal that oxidizes to multiple colours, bismuth is found in the minerals bismuthinite and bismite, but mostly recovered as a by-product of lead processing. It is used in medicine, cosmetics, low-melting alloys, fire detection/extinguishing systems, and in bullets. Bismuth also substitutes for lead in non-toxic alloys.

Pollucite

### Cesium (Cs) MB, ON

Silvery gold, soft, and ductile, cesium is extremely rare globally. It is found in granite pegmatites containing the minerals pollucite and lepidolite. Used in drilling lubricants and radiation monitoring equipment, it is also vital for atomic clocks, key to mobile networks, GPS, and the Internet.

Chromite

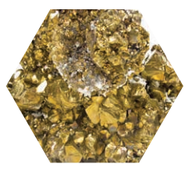
### Chromium (Cr) BC, ON

A lustrous, hard metal, chromium occurs mainly in the mineral chromite. It is tarnish resistant and takes a high polish. Chromium goes into stainless steel, highly resistant to corrosion and discolouration. Chromium alloys are used to plate auto parts and appliances and as superalloys in jet engines. Chromium is also a component of pigments used in paints, dyes, and stains.

Cobaltite

### Cobalt (Co) ON, QC, NL, AB, ON, NL, BC, SK, MB, NB, YT, NT

A bluish-white, lustrous, hard metal, cobalt is permanently magnetic and produced primarily as a by-product of nickel and copper mining. The leading use of cobalt is in the electrodes of rechargeable lithium-ion batteries. It is also used to produce magnetic, wear-resistant, and high-strength alloys, such as those used in gas turbine aircraft engines, and goes into electronic devices and batteries.



Chalcopyrite

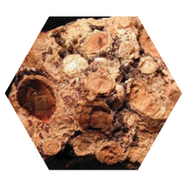
### Copper (Cu) BC, MB, ON, QC, NL, ON, QC, NL, SK, MB, NB, YK, NU, NT

A soft, reddish-orange metal, copper is derived from several minerals, including chalcopyrite and chalcocite. With high ductility, malleability, conductivity, and corrosion resistance, it is a major industrial metal. It goes into electrical wires, plumbing, industrial machinery, and construction materials, as well as clean technologies, such as solar cells, wind turbines, and EVs. Copper surfaces have been found to kill infectious microbes in high-touch areas.

Fluorite

### Fluorspar (F) NL

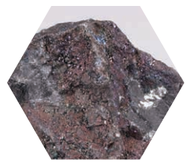
A non-metallic mineral also known as fluorite, fluorspar occurs in numerous colours. It is used in the metallurgical, ceramics, and chemical industries. It is key to producing hydrofluoric acid, a commonly used commercial chemical; to processing uranium and aluminum; and to manufacturing enamels, glass, and fibreglass, as well as steel and Portland cement.



Bauxite

### Gallium (Ga) ON, BC, SK, MB, QC, NB, NS, NT

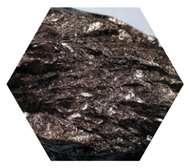
A soft, silvery metal obtained from bauxite and zinc ores, gallium is used in high-tech applications such as 5G wireless networks, smartphones, laser diodes, semiconductors, solar energy magnetic materials, and military devices. It is also useful in high-temperature thermometers, barometers, pharmaceuticals, and nuclear medicine tests.



Germanite

### Germanium (Ge) BC, NS, NT

A hard, lustrous, grey-white, brittle metalloid, germanium is mostly produced as a by-product of zinc mining, but is also found in the minerals germanite and argyrodite, and in silver, lead, and copper ores. Its most common use is in semiconductors, and it is also used in optical lenses, fibre optics, and solar cells.



Graphite

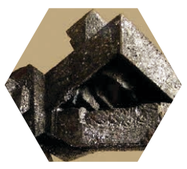
### Graphite (C) QC, BC, ON, QC

A soft, crystalline form of carbon, graphite occurs in metamorphic rocks such as schist and gneiss. Major uses include high-temperature lubricants, brushes for electrical motors, brake linings, gaskets, crucibles, electrodes, batteries, and fuel cells.

Uraninite

### Helium (He) SK

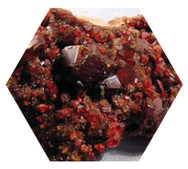
A colourless, odourless gas, helium is produced by the natural radioactive decay of elements such as uranium and thorium. It acts as a coolant for superconducting magnets and satellite instruments, and it provides an inert protective atmosphere for making fibre optics and semiconductors, and for arc welding.



Hematite

### High-Purity Iron (Fe) QC, NT, NL, QC, NL, QU

High-purity iron is an iron oxide such as hematite and magnetite containing more than 60% iron, and low amounts of impurities like phosphorus and sulfur. It requires less processing. It is essential for green steel manufacturing and decarbonization.



Sphalerite

### Indium (In) ON, BC, NS, YT

A silvery-white, lustrous metal, indium is produced mainly as a co-product of the zinc smelting process. Malleable and ductile, with a low melting point, it acts as a superconductor below a certain temperature. It is used in semiconductors, alloys, and solders. It is also used to make indium tin oxide, key to touch screens, flatscreen TVs, and solar panels.

Spodumene

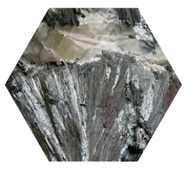
### Lithium (Li) MB, AB, SK, ON, QC

The lightest metal, lithium occurs in minerals such as spodumene and lepidolite and in lithium chloride salts dissolved in brine pools. Its most important use is in rechargeable batteries for cell phones, computers, EVs, and energy storage produced by solar panels and wind turbines. Lithium makes alloys lighter and stronger. Aluminum-lithium alloys are used in aircraft and high-speed trains. In medicine, lithium is used to treat depression and bipolar disorder.

Dolomite

### Magnesium (Mg) BC, AB, QC

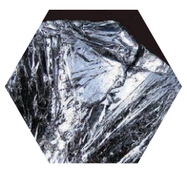
A light silvery-white metal, magnesium is found in the minerals magnesite and dolomite, but much is produced from seawater. One-third less dense than aluminum, it reduces the weight of many products. Alloyed with aluminum, it goes into aircraft and automobile construction. Other uses include electronic devices, power tools, medical applications, and construction.



Pyrolusite

### Manganese (Mn) NB, NL

A silvery-white metal derived from the minerals pyrolusite and manganite, manganese is the fourth most widely used metal in the world. It is essential to steelmaking, which uses 90% of production, and to lithium-ion batteries for EVs and other renewable energy applications such as electricity grid storage.



Molybdenite

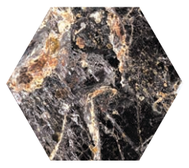
### Molybdenum (Mo) BC, ON, NB, YT

A silvery-grey metal derived from the mineral molybdenite, molybdenum is usually extracted as a by-product of copper and tungsten mining. It contributes corrosion resistance, strength, toughness, and hardness to steel alloys used for pipelines, jet engines, wind turbines, pharmaceutical and chemical mills, tanker trucks, and drills.

Garnierite

### Nickel (Ni) BC, MB, ON, QC, NL, AB, ON, QC, NL, YT

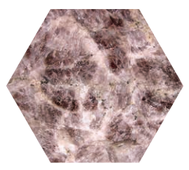
A hard, ductile metal, nickel occurs in minerals such as garnierite and pentlandite. It largely ends up in stainless steel, used in numerous applications, from medical equipment to kitchen appliances to aircraft and automobile construction. It is also used as an alloying agent, for electroplating, and in both nickel-cadmium batteries and lithium-ion batteries.



Columbite

### Niobium (Nb) ON, QC, BC, NT

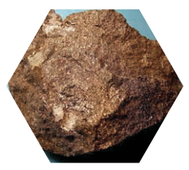
Derived from the minerals columbite and pyrochlore, niobium is a lustrous, grey, ductile metal. Niobium strengthens steel and makes it more corrosion resistant. Alloys containing niobium are used in jet engines and rockets, beams and girders for buildings and oil rigs, and oil and gas pipelines. It is used in superconducting magnets for particle accelerators and MRI scanners.



Anorthosite

### Phosphorus (P) QC, ON, BC

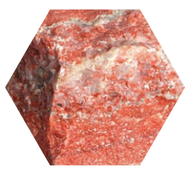
Phosphorous is a non-metal that occurs in the Earth's crust as phosphate in rocks such as anorthosite and carbonatite. Phosphorus is used in the production of fertilizers and in Lithium Iron Phosphate batteries, used in electric vehicles.



Pentlandite

### Platinum Group Metals (PGMs) MB, ON, QC, ON, QC, BC, YT, NU

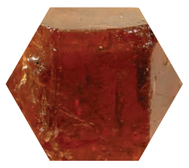
Platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), iridium (Ir), and osmium (Os) make up the platinum group metals. PGMs usually occur together in the same mineral deposits, mostly associated with nickel and copper. PGMs are largely used in catalytic converters for automobile exhaust systems to reduce tailpipe emissions, helping to improve air quality. Most electronic devices, including cell phones and computers, contain circuitry with PGMs.



Potash

### Potash (K) SK, NB

A group of minerals and chemicals that contain potassium, potash is an important ingredient in fertilizer, which supports plant growth, increases crop yield and disease resistance, and enhances water preservation.



Bastnäsite

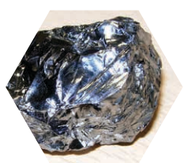
### Rare Earth Elements (REEs) ON, BC, QC, NB, NT, YT

A group of 15 lanthanide elements, along with yttrium and scandium, REEs are abundant in the Earth's crust but not in large concentrations. The most abundant source is the mineral bastnäsite, followed by monazite. Usually high-lustre silver, silvery-white, or grey metals, REEs are used mostly to make permanent magnets. They are key components of cell phones and other electronic devices, and of energy storage and clean energy technologies such as solar cells, high-density batteries, and wind turbines.

Hedenbergite

### Scandium (Sc) QC

Often classified with REEs because of similar properties and found in the same ore bodies, scandium is principally used for solid oxide fuel cells and high-performance aluminum-scandium alloys used in the auto and aerospace industries. Other uses include ceramics, electronics, lasers, lighting, and radioactive isotopes.



Silicon

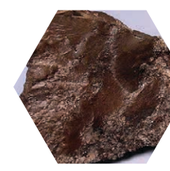
### Silicon Metal (Si) QC

Silicon Metal is a grey, semiconducting metal which has been refined to an extremely high purity. Silicon metal is not sourced directly from mined minerals it is produced through an industrial process. Ultra-high purity silicon metal (99.99%) is essential to the manufacture of chips and semiconductors, used in electronics.

Tantalite

### Tantalum (Ta) MB, BC, ON, QC, NT

A rare, blue-grey, very hard metal, tantalum is almost always found with niobium in the minerals columbite and tantalite and is also obtained as a by-product of tin extraction. About half of all tantalum produced is used by the electronics industry, making electricity storage possible in miniature capacitors used in aviation electronics, computers, and other electronic devices.



Chalcocite

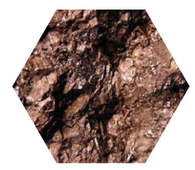
### Tellurium (Te) ON, ON, QC, BC

Mainly a by-product of copper-bearing mineral processing, tellurium is a silvery-white metalloid. It has applications in solar panels, rubber production, electronics, and more. Ultra-high purity tellurium can be used for semiconductor technologies used in medical imaging, advanced security and military systems, and for next generation solid-state batteries.

Cassiterite

### Tin (Sn) QC, NB, NS

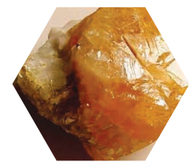
A silvery-white metal derived from the mineral cassiterite, tin has multiple uses. It is used for plating, coating, and polishing; solders; flat panel displays; alloys such as bronze and pewter; battery electrodes; dental applications; marine applications; window glass making in electric vehicles, solar energy systems, 5G telecommunications, heat harvesting, hydrogen production and in carbon capture catalysts.



Ilmenite

### Titanium (Ti) QC, QC

A hard silvery metal derived from the minerals ilmenite and rutile, titanium is lightweight, corrosion resistant, and able to withstand extreme temperatures. Most titanium is turned into titanium dioxide, used to improve whiteness in products from toothpaste to paint to food products. Lightweight titanium alloys are widely used in the aerospace industry. As metallic biomaterials, titanium and titanium alloys are used for dental implants, hip replacements, and heart pacemakers.



Scheelite

### Tungsten (W) MB, NB, NS, NL, YT, NT

A dense, silvery-white, lustrous metal, tungsten is derived mainly from the minerals wolframite and scheelite. It mostly goes into tungsten carbide, ideal for cutting and wear-resistant applications in construction, metalworking, mining, and oil and gas drilling. It also goes into alloys and specialty steels; aerospace and defence applications; electrical, electronic, heating, lighting, and welding applications; and various chemical applications.

Uraninite

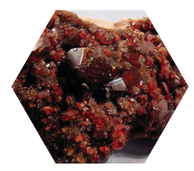
### Uranium (U) SK, ON, NL

One of the densest materials known, occurs in the minerals uraninite uranium and brannerite. It is silvery white, malleable, ductile, and radioactive and is mostly used in the nuclear power industry to generate electricity. It also powers nuclear submarines and goes into nuclear weapons.

Vanadinite

### Vanadium (V) ON, QC

A soft, shiny, silvery-white metal, vanadium occurs in crude oil and numerous minerals, including vanadinite and carnotite. Produced mainly as a by-product, its main use is in high-strength steels for construction, auto parts, heavy equipment, industrial tools, medical devices, turbine engines, and military vehicles. Emerging vanadium redox flow battery (VRFB) technology is a promising way to store energy from renewable sources.



Sphalerite

### Zinc (Zn) BC, MB, ON, QC, NB, YT, BC, MB, ON, QC, SK, NS, NL, NT

A blue-grey, metallic element, zinc is found primarily in the mineral sphalerite. Most zinc is used to galvanize metals to prevent rusting. Galvanized steel is used in many industries, including agriculture, solar, automotive, construction, and telecommunication. Zinc goes into alloys for die-castings in the automobile, electrical, and hardware industries, and into brass, bronze, and nickel silver. About 30% of worldwide zinc production comes from secondary or recycled zinc from such sources as scrap galvanized steel and batteries.

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Version française disponible. PRINTED IN 2025