UNDERSTANDING NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

A GREENLAND PERSPECTIVE

As the name suggests, NORM is natural material found in the environment that contains radioactive elements. NORM primarily contains the elements uranium, thorium and potassium and often small amounts of the daughter products formed from natural breakdown.

OVERVIEW

Greenland is a mineral rich country, with an abundance of metals that are essential to a modern lifestyle, some of which can help reduce the global reliance on oil and gas. This includes rare earth elements, zirconium, copper, nickel, graphite, niobium and of course uranium.

Each metal, when mined, will find its way to a different application based on its properties, be that conducting electricity, hardening steel, enabling high strength permanent magnets, emitting light, allowing the storage and transport of energy, or even creating energy itself.

While mining these elements is essential, mining is not suitable everywhere. However, a well-planned, highly regulated and monitored mine, designed with extensive technical, environmental and social data, can provide long term local and national benefits, while not causing any significant impacts to the environment.

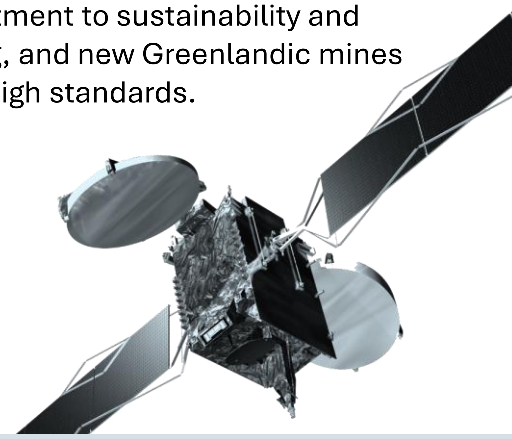
MODERN MINING

Mineral exploration and mining in Greenland has a long history but today mining accounts for less than 5% of the Greenlandic economy. The future looks bright, should the Greenlandic people support and encourage the growth of this industry and legislative clarity is provided to investors.

Like the rapid changes we see daily in transport and communication, mining has evolved dramatically through the adoption of technology.

Environmental management and safety is continually improving, advanced extraction methods reduce waste, while real-time monitoring ensures swift responses to minimise hazards.

Satellite and laser tracking have enhanced site security. Stricter regulations have improved worker safety and reduced exposure to hazardous materials. These advancements reflect the industry's commitment to sustainability and human well-being, and new Greenlandic mines will follow these high standards.



WHAT IS RADIATION?

Radiation is energy moving through space. While it cannot be seen, it is easy to accurately measure and record. Natural radiation is all around us, in the rocks and soil, the food we eat, the air we breathe and cosmic rays from space. This natural background radiation gives everyone a 'dose' of about 2 or 3 millisieverts per year (mSv/yr), the exact amount determined by the local rock we live on and our lifestyles (the average dose in Narsaq is 5-6 mSv/yr).

'Man-made' radiation is also part of our everyday life. It provides the essential function to x-rays, organ scans, smoke detectors, and in industrial gauges, as well as in the sterilisation of medical equipment and certain foods.

COMMON TYPES OF RADIATION

- **Alpha particles** (α), which can't penetrate a piece of paper, but can be hazardous if ingested in high concentrations
- **Beta particles** (ß), which can penetrate a centimetre or so into the human body, but are blocked by a thin sheet of metal
- **Gamma rays** (γ), which can pass through the body and require thicker materials such as lead to stop them, but don't cause harm at low levels.

HOW IS RADIATION MEASURED?

The amount of radiation emitted by any natural or man-made radioactive material is measured in *becquerel* (Bq). The radiation dose absorbed by a person (that is, the amount of energy deposited in human tissue by radiation) is measured using the SI unit *gray* (Gy). Some common examples are provided from the CDC (USA) in the table to the right.

From a human health perspective, Equivalent Dose is the most important, measured in the SI unit *sievert* (Sv). *Millisieverts* (mSv) are often used, 1 mSv is 1/1000 of a Sv.

The Equivalent Dose method recognises that the effects of alpha, beta and gamma radiations are not equal in biological risk even if the radiation dose is the same. Alpha radiation is the most impactful, with sources including extremely scarce radium, plutonium and polonium isotopes.

Workers in industries that may encounter elevated radiation wear dosimeters that record exposure over time. If levels (in Sv) are above recommended limits, workers will rotate through roles to limit exposure and risk.

The content of radioactive elements in a material is measured in *parts per million* (ppm) or *mg/kg*. While this value is a guide the ppm value of one element does not define radiation dosage.

WHAT ARE NATURALLY OCCURING RADIOACTIVE MATERIALS (NORM)?

Radiation is released when atoms of radioactive elements naturally break down or "decay." Radioactive elements like uranium (U) and thorium (Th) are unstable and break down into other elements, releasing energy as they do so. The rate of decay, measured as 'half-life', varies from billions of years to seconds. Decay stops when a stable element forms, often lead.

Uranium is mildly radioactive. The soft radiation (low penetrating power) it gives off and its long half-life and low activity mean that it is not particularly hazardous to humans. Nonetheless, uranium has the potential to cause negative health effects if improperly handled, and especially if inhaled.

All rocks and soils contain traces of naturally occurring radioactive material. Building materials like concrete and granite benchtops contain NORM and may emit safe, but detectable, radiation.

Commercial fertilizer is a common NORM source. In 2016, *Kratz et al.* investigated uranium content of phosphate fertilizers used in German agriculture and found U ranged from 14.3 to 141 ppm. A further study by *Verbeeck et al.* in 2020 tested 414 fertilizer samples which contained from 0.04 to 242 ppm uranium. The German environmental agency proposes a 50 ppm U limit in phosphate fertilizers.

Natural radiation levels have remained the same for billions of years. They pose no risk to life or health, except in rare cases. Radiation from NORM is measured by aeroplane and sampling.

Uranium and thorium concentrations are well known across Europe, with highest natural levels in Southeastern Sweden, northern Portugal, and central France.

ACTIVITY	Radiation Dose
Whole Body CT Scan (one)	20 mSv
Mammogram (one)	0.42 mSv
Cosmic Radiation at Sea Level (Annual)	0.3 mSv
Terrestrial Radioactivity (Annual)	0.21 mSv
Chest X-Ray (one)	0.1 mSv
Living Close to a Nuclear Power Station (Annual)	0.01 mSv
3-hour plane trip (one)	0.01 mSv

URANIUM PRODUCTION & CONSUMPTION

In 2024, over 30 countries included nuclear power in their energy mix, including Sweden, France, Finland, USA, Japan, Canada and the UK. France's utilization is the highest, with 70% of power coming from nuclear.

While substantial research is underway for thorium reactors, today all nuclear power utilizes uranium. Leading uranium producing countries include Canada, Australia, Kazakhstan and Namibia.

According to international standards, radiation should be regulated at a level where any exposure above natural background radiation is kept "as low as reasonably achievable" (ALARA). Individual dose limits are set at 1 millisievert (mSv) per year for the general public and 100 mSv per year for occupational exposure, averaged over 5 years; meaning any level exceeding these limits needs to be regulated and managed carefully.

MINING URANIUM IN FINLAND

In 2024, Finland became the first European Union member in recent times to produce uranium, marking a historic milestone in European energy policy.

The Talvivaara Mine near Sotkamo, owned by Terrafame (70% Finnish government owned), is a multi-metal project, extracting nickel and zinc, with uranium as a by-product. The uranium grade is approximately 20 ppm.

Finland's Radiation and Nuclear Safety Authority (STUK) approved the operational plans of Terrafame Oy, permitting full-capacity production, with a target of 200 tons of uranium per year by 2026. This is around 75% of consumption at Finland's Olkiluoto Island nuclear power plant, creating a significant step towards energy independence and supply security.

The extracted uranium is shipped internationally for further processing. Canada's Cameco Corporation provides technical support and uranium offtake.

CRITICAL RAW MATERIALS & GREENLAND

As the world relies more on low-CO_2 energy, electric transport, AI, and robotics, critical raw materials are increasingly important. New technologies require high-purity minor metals like germanium, gallium, indium, and rare earth elements.

Unlike copper, iron, zinc, and aluminium, these minor metals lack established supply chains and involve complex processing.

Securing long-term access to them is a major geopolitical challenge. The European Union's Critical Raw Materials Act (CRMA), enacted on May 23, 2024, aims to ensure a sustainable, resilient supply for the EU's green and digital transitions.

By 2030, the CRMA targets extracting 10%, processing 40%, and recycling 25% of the EU's annual critical raw materials consumption. It also limits reliance on any single non-EU country to 65% per strategic material.

Greenland is a key partner in this strategy, possessing 25 of the 34 critical minerals on the EU's list, including rare earth elements, graphite, and platinum group metals.

In November 2023, the EU and Greenland signed a Memorandum of Understanding to develop sustainable raw materials value chains. This partnership aligns with the CRMA's goals, reducing reliance on dominant global suppliers.

By investing in Greenland's mining infrastructure and fostering sustainable mine operations, the EU aims to strengthen its strategic autonomy, ensuring industrial resilience and the success of its green and digital agendas.

DID YOU KNOW?

Uranium, like all elements, formed in the "big bang" at the time of universe formation. Because of radioactive decay, the amount of uranium on earth decreases slightly each year, and will never be replaced

THE GREENLAND APPROACH

Exploration for uranium holds a complex place in Greenlandic history. While commercial mining of uranium has never occurred, test mining in 1980 saw a small batch of ore shipped to Denmark.

When Greenland gained self-governance in 2009, the country also gained self-management of mineral resources. In 2013 a zero-tolerance approach to uranium mining was overturned in the Inatsisartut (Legislative Assembly), facilitating exploration and potential future production. In 2016, Greenland and Denmark signed an agreement to cooperate on the export of uranium to ensure the future sale of radioactive material was appropriately controlled.

In 2021 the Inuit Ataqatigiit (IA) party was elected to form Government, having campaigned on a platform to re-instate the zero-tolerance policy for uranium. On 9th of November 2021, twelve parliamentary members voted in favor vs nine against, to place an upper limit of 100 parts per million (ppm) uranium for exploration or on mining projects, even where uranium is a by-product or is not recovered. This was ratified by the Inatsisartut as “Act 20” . The government can impose fines for violations, & companies may face criminal liability under Greenland's Criminal Code.

The 100 ppm limit for uranium exploration or mining is a non-traditional method of restricting the uranium exploration and mining industry, and one which is not applied in any other jurisdiction. The 100 ppm limit does not account for radiation energy or the biological effects of radiation and is not an industry standard approach.

ABOUT ETM & OUR COMMITMENT TO GREENLAND

Energy Transition Minerals (ETM) is an Australian public mining company focused on responsibly developing critical mineral resources. ETM holds rights to the Kvanefjeld/Kuannersuit project in southwest Greenland, first granted in 2007. Kvanefjeld was initially discovered by Danish geologists in 1956 and is now recognized as one of the world’s largest rare earth element deposits, with the capacity to supply critical raw materials for renewable energy and technology for many decades to come.

ETM has conducted extensive research and invested 18 years in understanding both the mineral deposit and the surrounding environment and community. Utilizing this knowledge allows a future mining project to be designed in a way that minimizes ecological and social impact while adhering to Greenlandic and best-practice international standards.

The company is committed to working with local communities, addressing concerns, and incorporating traditional knowledge into project planning. By fostering economic opportunities such as job creation and infrastructure development, ETM seeks to balance global demand for minerals with a strong commitment to Greenland’s environment and people. The company also emphasizes transparent communication with stakeholders, ensuring that local voices are heard throughout the development process.

ETM actively collaborates with Greenlandic authorities, researchers, and businesses to create long-term benefits. Additionally, it invests in cutting-edge mining technologies to reduce environmental risks and enhance sustainability. Through these initiatives, ETM aims to support Greenland’s economic growth while ensuring responsible resource extraction that aligns with global environmental and ethical standards.

REFERENCES AND FURTHER READING

Further reliable information about radioactive materials is available from:

Naturvårdsverket (Sweden)
https://www.naturvardsverket.se/

STUK, Radiation & Nuclear Safety Authority (Finland)
https://www.stukinternational.fi/

World Nuclear Association
https://world-nuclear.org/

Nuclear Energy Institute
https://www.nei.org/home

Australian Radiation Protection & Nuclear Safety Agency (ARPANSA)
https://www.arpansa.gov.au/

French Authority for Nuclear Safety & Radiation Protection - ASNR
https://www.french-nuclear-safety.fr

Canadian Nuclear Safety Commission
https://www.cnsc-ccsn.gc.ca/eng/

Danish Health Authority
https://www.sst.dk/en/English