Erasmus+
Enriching lives, opening minds.

Raw Materials: Why they matter, are essential for a sustainable future – and why some are “Crititical”.

By the end of this Lesson, you will know about:

- What makes a raw material “critical”
- The key characteristics of critical raw materials
- The importance of critical raw materials in modern technology
- Where and how they are mined
- Supply chain risks related to critical raw materials & how they occur

Co-funded by the Erasmus+ Programme of the European Union
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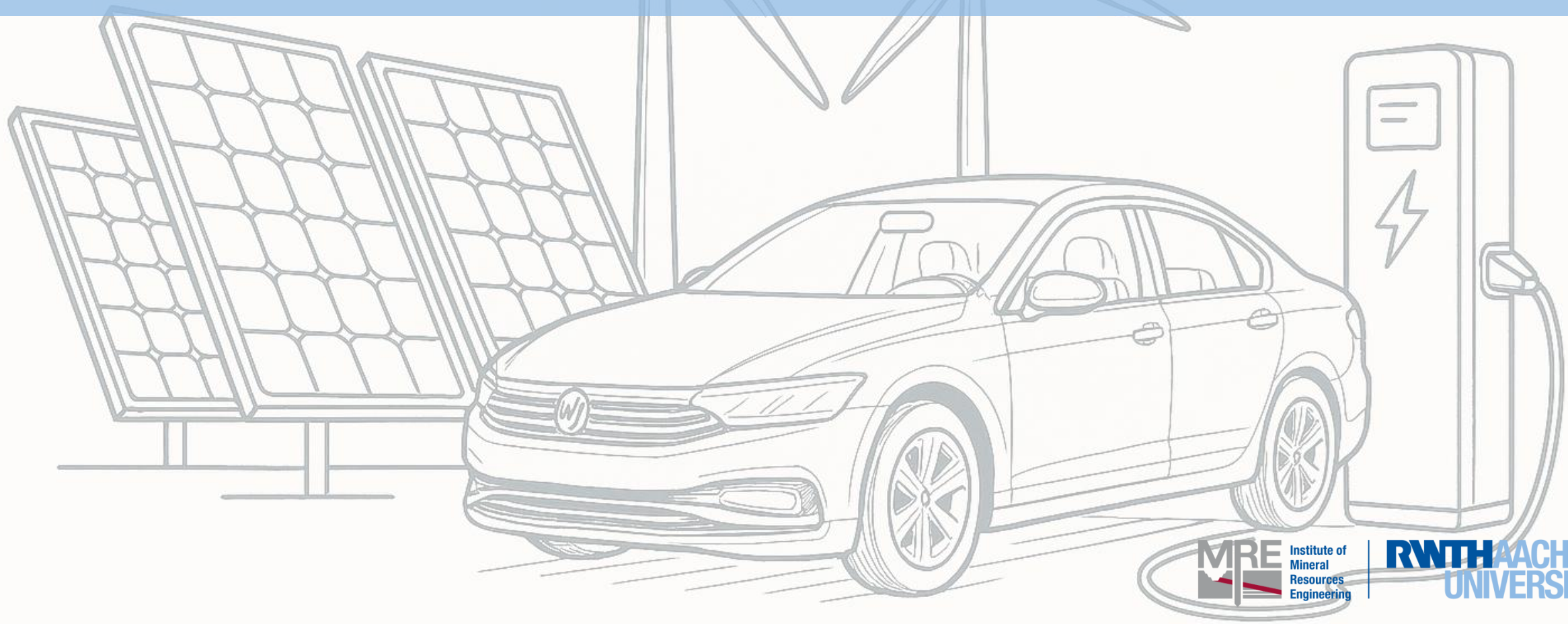
The Low-Carbon Paradox: Fighting Climate Change With Ressource-Intensive Tech



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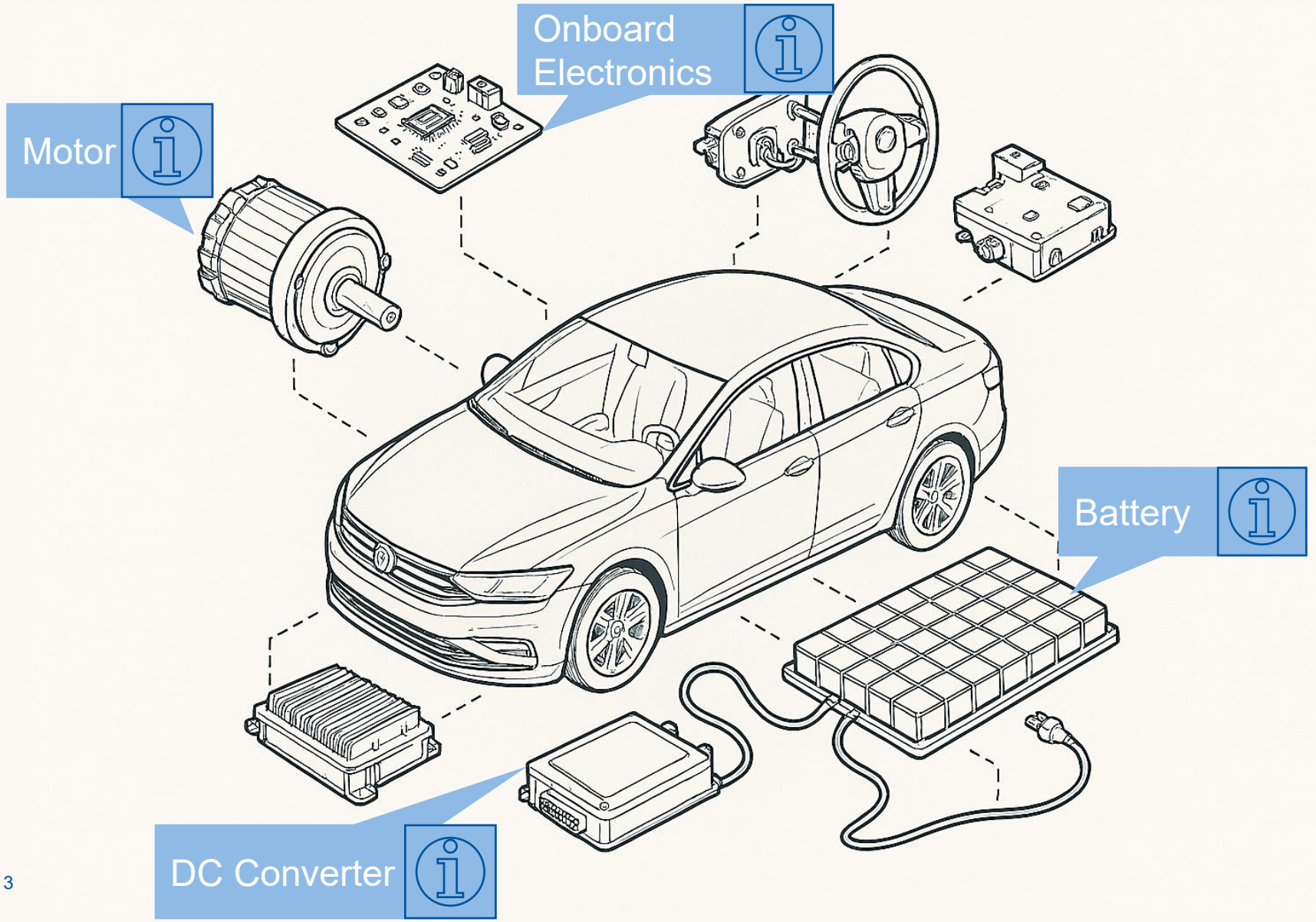
The Electric Car: Clean, but Resource-Hungry



What does it take to build an electric car?

It's not just clean energy – it's also **lots of materials**.

Click on the components to explore which **critical raw materials** are inside.

See What's Inside an EV

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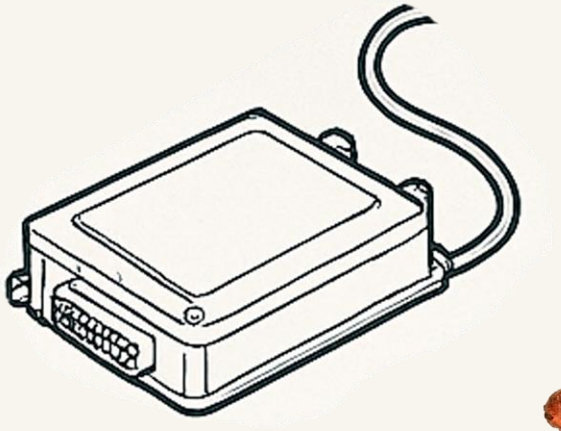
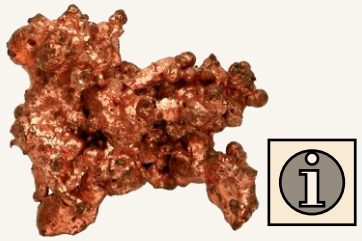
DC/AC Converter – The Power Switch





Short Facts:

- Converts battery's DC power into AC to drive the motor.
- Needs **Gallium, Copper**, and sometimes **Rare Earths**.
- **Gallium Nitride** (Ga N) makes power chips more efficient and smaller.

Gallium is so soft it can melt in your hand.

Do you recognize the different Minerals? Click on the Minerals to see their names and Purposes!

Return to Car Overview

The Heart of the Car: The Battery Pack

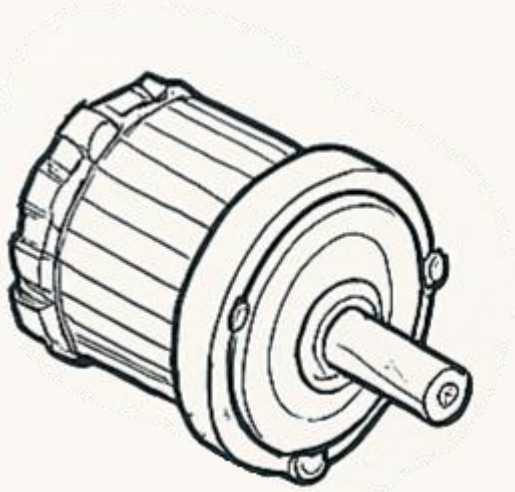
Short Facts:

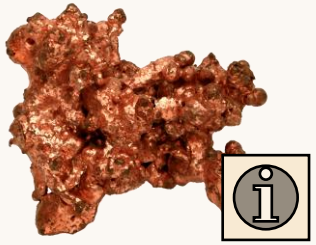
- The EV battery is the largest single consumer of raw materials.
- Contains: Lithium, Cobalt, Nickel, Graphite
- Up to 40–50% of all critical materials in an EV are here.

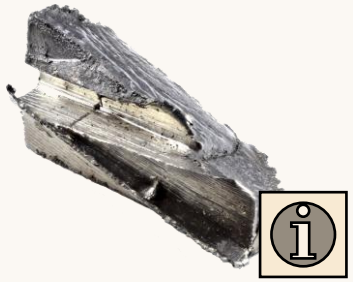
Do you recognize the different Minerals? Click on the Minerals to see their names and Purposes!

Return to Car Overview

The Muscle: Electric Drive Motor



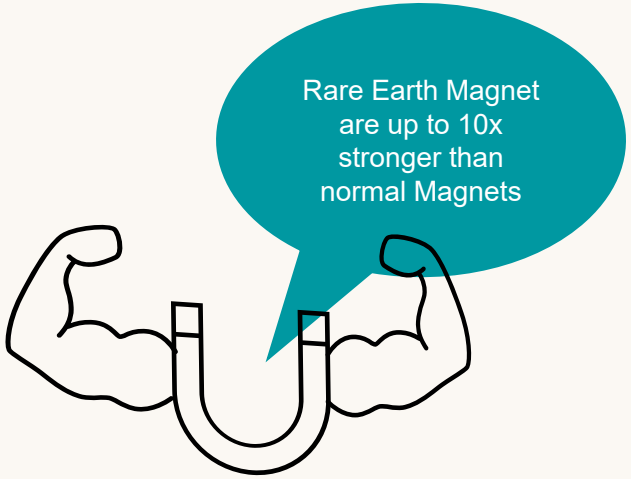




Do you recognize the different Minerals? Click on the Minerals to see their names and Purposes!

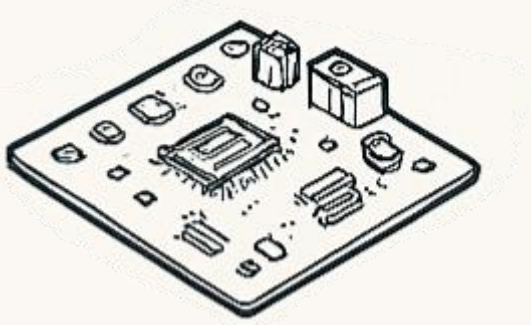
Short Facts:

- Many EVs use **permanent magnet motors**
- Core materials: **Neodymium**, **Dysprosium**, **Copper**



Return to Car Overview

The Brain – Onboard Electronics



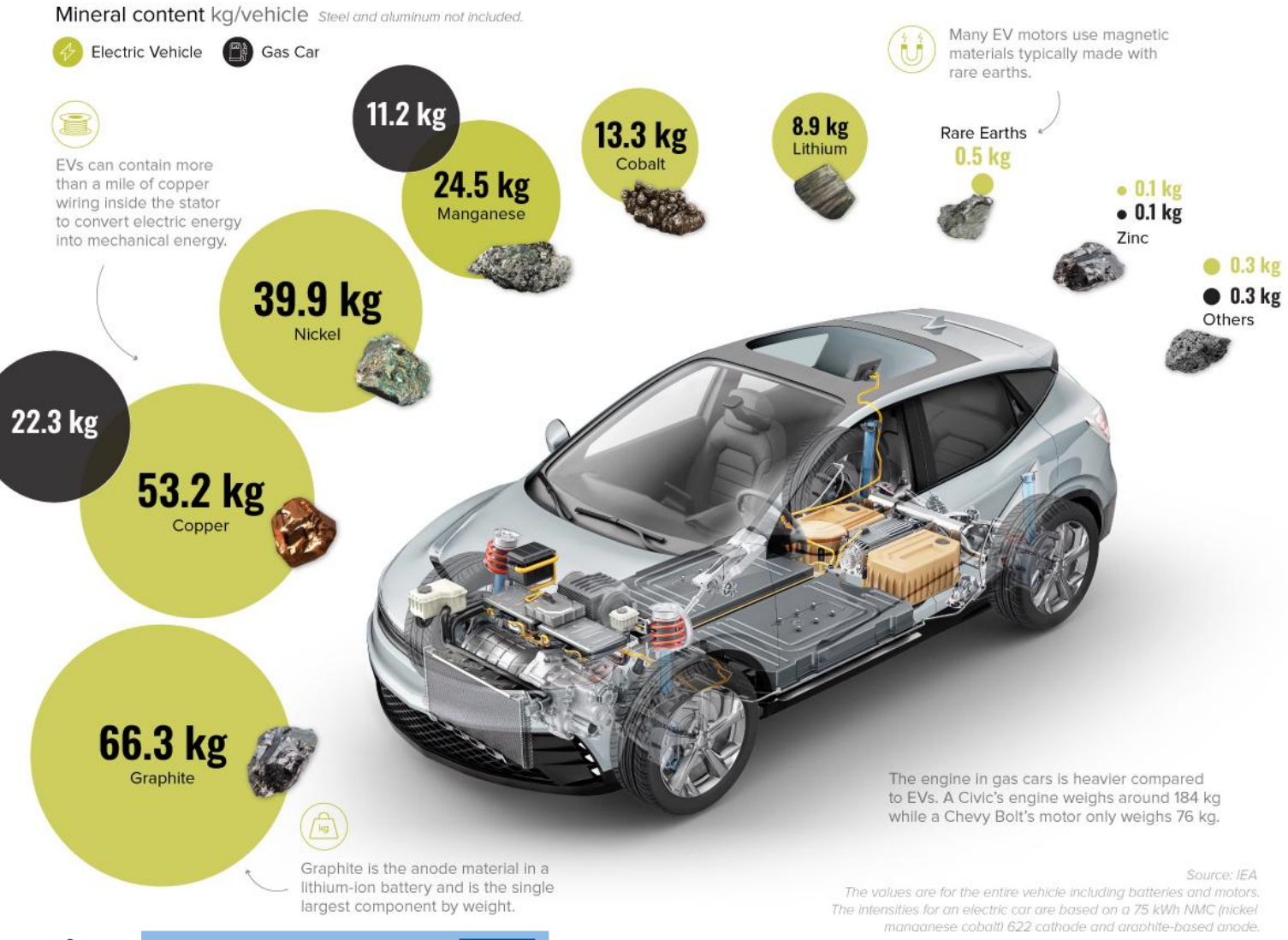
Short Facts:

- Includes computers, sensors, infotainment, safety systems.
- Contains **Gallium**, **Rare Earths**, **Tantalum**, **Tin**.
- Up to **3,000 chips** per car!

Do you recognize the different Minerals? Click on the Minerals to see their names and Purposes!

Return to Car Overview

Minerals in Electric Cars vs. Fossil fueled Cars



Electric vehicles require a wider range of Minerals for their motors ans Batteries copared to fossil fueled cars

In fact: An EV contains up to 6 times more Minerals!

See Where our Resources come from

Return to Car Overview

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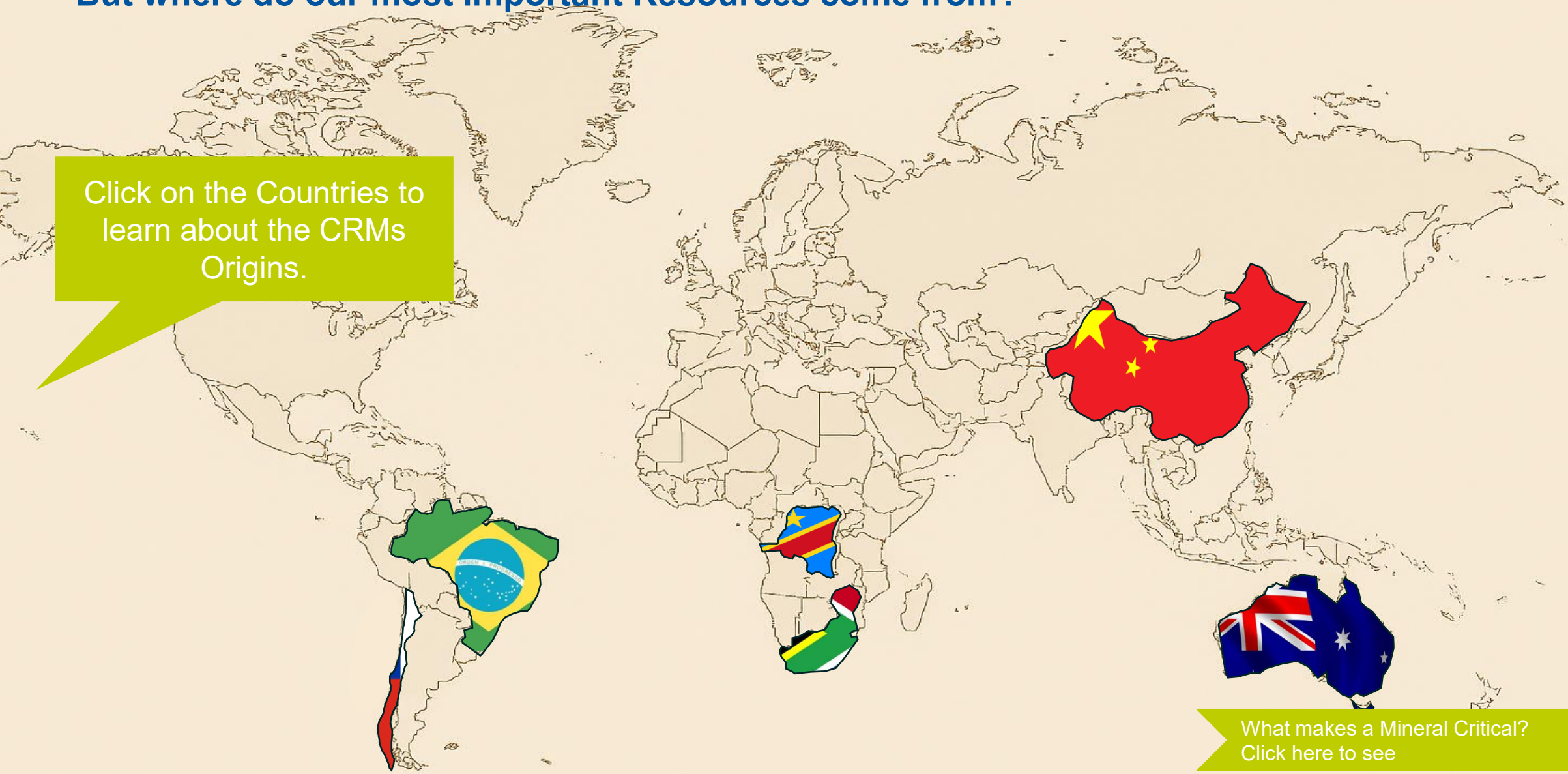
But where do our most important Resources come from?



Click on the Countries to learn about the CRMs Origins.

What makes a Mineral Critical?
Click here to see

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Brazil

- **Key Raw Materials:**
  - **Niobium (>90 % of Global Supply)**
  - Bauxite (Aluminum) and Iron Ore
  - Growing Graphite, Lithium and Rare Earth Sector

- **Other mined Critical Minerals:**
  - Manganese, Tantalum, Nickel

Mining Type:

- **Industrial** for niobium, iron ore
- **Artisanal Mining is common** for **gold & tantalum** – with **Amazon-related ESG issues**

Learn more about Mining Types

Return to Worldmap

China

- **Key Raw Materials:**
  - **Rare Earths (mining and >85% global processing)**
  - **Graphite** (mining & nearly all global refining)
  - **Gallium** (95% of global production)
  - Lithium refining (dominates processing of imported lithium)
- **Other mined Critical Minerals:**
  - Tungsten, Magnesium, Fluorspar, Antimony
- **Why is it a supply risk?**
  - Bottleneck: **Refining capacity & export control**
  - Heavy **state control of supply chains**: Imposed **export bans** on gallium & germanium (2023)

Mining Type:

- **Fully industrialized and state-controlled**
- Strict central coordination, but **regional environmental issues**
- Especially relevant for **REE processing**

Learn more about Mining Types

Return to Worldmap

Australia

- **Key Raw Materials:**
  - **Lithium**
  - Also: Nickel, Rare Earths (growing), Bauxite (Aluminium)
- **Other mined Critical Minerals:**
  - Cobalt, Graphite, Manganese (exploration stage)
- **Why is it a supply risk?**
  - **Bottleneck: Processing/export dependence on China**
  - Australia mines → **China refines**
  - Geographic distance and limited refining capacity

Mining Type:

- **Large-scale industrial mining only**
- Mined from Spodumene Rocks in Open Pit Mines
- **High ESG standards** and transparency

Learn more about Mining Types

Return to World map

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South Africa

- **Key Raw Materials:**
  - Platinum Group Metals (PGMs) (world leader)
  - Also: Vanadium, Manganese, Chromium
- **Other mined Critical Minerals:**
  - Rare Earths (exploration), Titanium
- **Why is it a supply risk?**
  - Bottleneck: Political risk, energy shortages, unstable labor conditions
  - High export dependency

Mining Type:

- **Industrial** operations dominate
- ASM exists (gold, illegal mining), but **not key for CRMs**
- **Energy shortages** affect Operation

Learn more about Mining Types

Return to World map

Congo

- **Key Raw Materials:**
  - Cobalt (**~70% of global mine production**)
  - Also: Copper (major producer)
- **Other mined Critical Minerals:**
  - Tantalum, Tin, Gold (often in informal mining)
- **Why is it a supply risk?**
  - Bottleneck: Mining conditions & ESG risks
  - Linked to child labor, human rights issues
  - Politically unstable region
- **China controls much of the refining, even of Congolese ore & mines**

Mining Type:
- **~20–30% of cobalt** comes from **ASM**
- Often **unsafe** and involves **child labor**
- Remaining production is **industrial (Chinese-owned)**
  → **High ESG risk**, low transparency

Learn more about Mining Types

Return to World map

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Chile

- **Key Raw Materials:**
  - **Lithium** (2nd largest producer, from brines)
  - **Copper** (world's largest producer)
- **Other Critical Minerals:**
  - Molybdenum (important for steel)
- **Why is it a supply risk?**
  - **Bottleneck:** Water-intensive lithium production in **fragile ecosystems** (Atacama)
  - High reliance on **foreign processing**
  - Political debates on nationalization & royalties

Mining Type:

- **Industrial mining (Salar de Atacama)** for lithium (brine)
- **Environmental conflicts** with Indigenous communities

Learn more about Mining Types

Return to World map

Industrial (Large Scale) Mining vs. Artisanal (Scale) Mining

Key Facts:
- Often informal mining operations
- Low capital
- Labor intensive

Challenges:
- Dangerous working conditions
- Child labor
- No regulations & controls

See Mining realities in Congo

Learn more about LSM

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Industrial (Large Scale) Mining vs. Artisanal (Scale) Mining

Key Facts:
- Industrial mining operations
- Multi-national companies
- High skill levels and investments required

Challenges:
- Deforestation
- Meeting ESG-standards
- Large scale tailings & mine waste

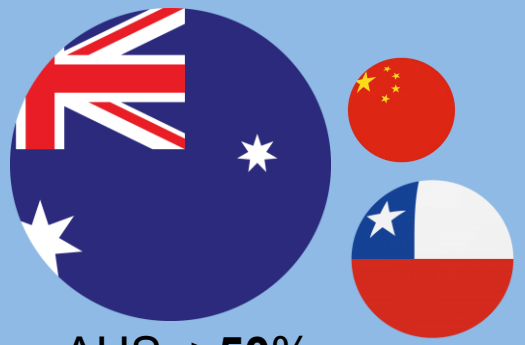
See Mining realities in Congo

Learn more about ASM

Lithium – Mineral Profile

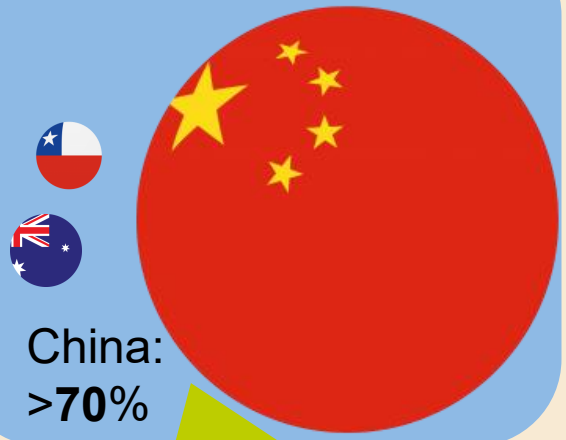
Why am I a Critical Raw Material?

Top Producers 2024:



AUS: >**50**%

Top Refiners 2024:



China: >**70**%

Key Facts:

- Essential for **high energy density** in lithium-ion batteries
- Key for EVs, phones, grid storage **8–10 kg per EV battery**

- EU imports almost 100% of its lithium
- Refining dominated by China
- Demand expected to increase 5x by 2030

Why is this a supply risk?

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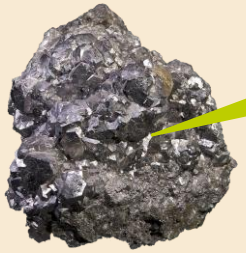
Kobalt



Why am I a Critical Raw Material?

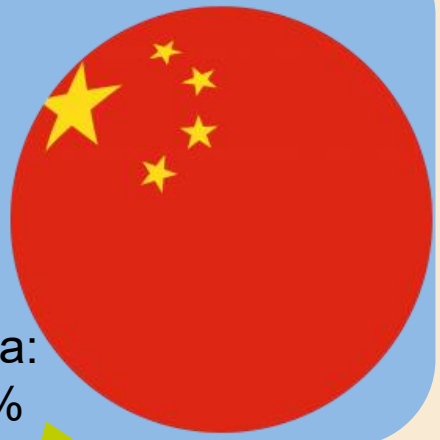
Key Facts:

- Essential for **high energy density** in lithium-ion batteries
- One of the most Critical & geopolitical sensitive Raw Materials

Top Producers 2024:

DRC >79 %

Top Refiners 2024:



China: **>70%**

- 70% is mined in Congo (DRC)
- Value Chain is dominated by Chinese Companies
- Mining under harsh conditions

Why is this a supply risk?

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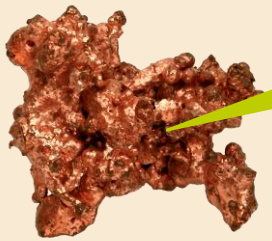
Copper



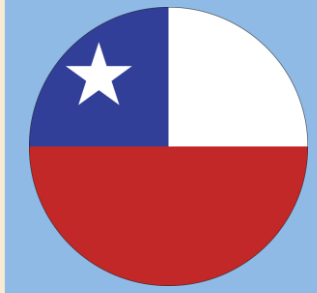
Why am I a Critical Raw Material?

Typpical EV-Contetnt 50kg

Key Facts:

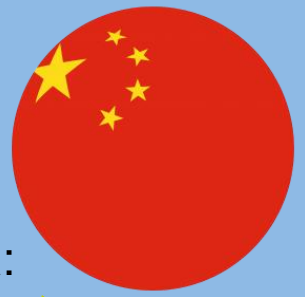
- **Essential for electric wiring, due to the highest electrical conductivity of all non-precious metals.**
- **Critical for energy transmission in the green transition.**

Top Producers 2024:



DRC >79 %

Top Refiners 2024:



China: **>70%**

Why is this a supply risk?

- EU imports almost 100% of its lithium
- Refining dominated by China
- Demand expected to increase 5x by 2030

Return to Car Overview

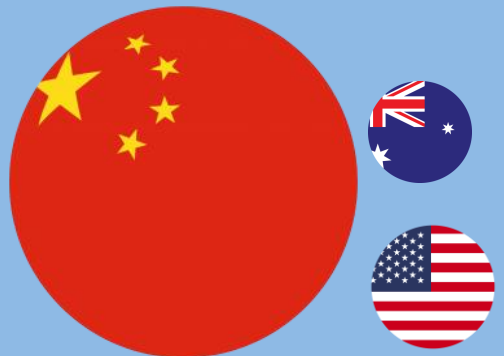
Rare Earth Elements

Why am I a Critical Raw Material?

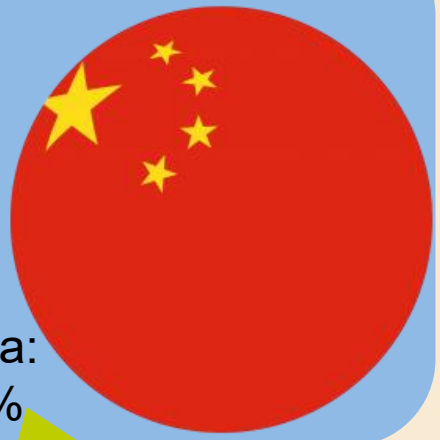
Key Facts:

- Group of 17 metals, key ones for EVs: Neodymium, Dysprosium, Praseodymium.
- Used in permanent magnets for EV motors, wind turbines, electronics.

Top Producers 2024:



Top Refiners 2024:



China: **>80%**

- EU imports almost 100% of its lithium
- Refining dominated by China
- Demand expected to increase 5x by 2030

Why is this a supply risk?

Return to Car Overview

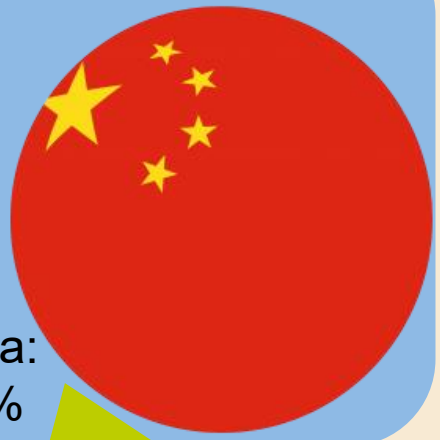
Graphite

Why am I a Critical Raw Material?

Top Producers 2024:

DRC >79 %

Top Refiners 2024:



China: **>70%**

Why is this a supply risk?

Key Facts:

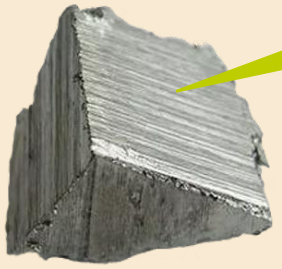
- Anode in **lithium-ion batteries**.
- Natural graphite is light, conductive, heat-resistant.
- Needed for **battery capacity & stability**.

- EU imports nearly 100% of battery-grade graphite.
- China controls >**90% of battery grade refining (most important)**
- Demand expected to increase 5x by 2030

Return to Car Overview

Gallium

Why am I a Critical Raw Material?



Top Producer and Refiner 2024:

China with over 95%

Strong monopoly position mining and processing

Key Facts:

- Used in high-tech semiconductors
- Enables high-efficiency power electronics, LEDs, solar cells, 5G

- Mined as a by-product of **bauxite and zinc refining**.
- China (>95% global output).
- EU imports >90% of gallium from China

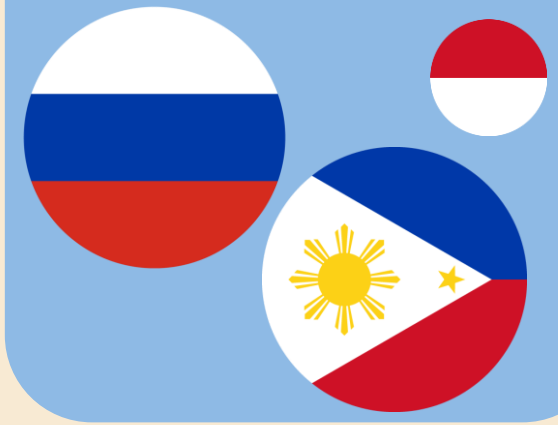
Why is this a supply risk?

Return to Car Overview

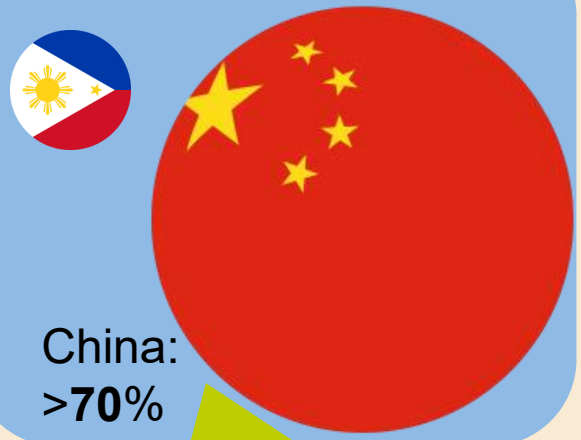
Nickel

Why am I a Critical Raw Material?

Top Producers 2024:



Top Refiners 2024:



China: **>70%**

Why is this a supply risk?

Key Facts:

- Used in **battery cathodes to increase energy density**
- Major Use also in **stainless steel** production

- **Top Producers:** Indonesia (~50%), Philippines, and Russia.
- “Class 1 Nickel” for batteries is refined **mainly in China.**
- high dependence on a few producers

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Deep Dive: Precious metals for Energy transmission & Climate Change

Example on Cobalt & Rare earth Elements

The **DRC** supplies **most** of global cobalt.

Processed mainly in **China**, which dominates the global refining market.

Raises questions about **ethics**, **sustainability**, and **dependency**.

China controls over 60% of mining and **almost all of refining**.

In 2025, **China restricted exports**, causing supply fears in the EU.

Their dominance gives China **strategic leverage** in global trade.

Cobalt Mining in DRC

LSM Mining in DRC

Rare Earth Elements

Return to Car Overview

Return to Car Overview

Cobalt

Mining Realities in DRC

Mining

>70% of global cobalt mine production

Many Mines are Chinese-Owned

Refining

>70% of global refining capacity

Chinese Companies buy from artisanal Miners

Consumption

imports almost all cobalt

The Coblat Price rises each step in the Value chain

refining is **energy-intensive, costly, concentrated in one country**

EU relies on **foreign Cobalt** and can't intercept the current market

Return to World map

Deep Dive Overview

Artisanal Mining

Mining Realities in DRC

- Provides income for hundreds of thousands of people
- Very labor-intensive, often unregulated
- Manual tools, no safety gear, no contracts
- Risks: child labor, cave-ins, toxic wastes
- Wages: only a few dollars per day

Artisanal and informal mining is **is not inherently illegal.**
In politically unstable or conflict-affected areas these operations are more vulnerable to criminal exploitation and environmental or social harms, as in the case of the Democratic Republic of the Congo

Mining Sites in DRC

- Not all copper deposits contain significant cobalt, but nearly all cobalt in the country is sourced from copper deposits
- Cobalt, vital for electric vehicle batteries, is sourced from both industrial and artisanal mines.
- The government created Entreprise Générale du Cobalt (EGC) to regulate artisanal cobalt production.

- The DRC produces about 63% of the world's cobalt,
  - with about 80% from **industrial copper mines**,
  - and the remaining 20% gathered by **artisanal mining.**

Return to World map

Large Scale Mining

Mining Realities in DRC

- Industrial (large) Companies operating
- Chinese-owned Cobalt mines
- Heavy Machinery and Tools
- Mine Waste & Pollution
- Most profits leave DRC

The largest shareholders in most copper mines in the DRC are foreign corporations.

Chinese companies have become major holders in various copper mines in the DRC

- **China Nonferrous Metal Mining Group**
- **China Railway**
- **Jinchuan Group**
- **Zhejiang Huayou Cobalt**

Rare Earth Elements

What are REEs?

Group of 17 critical metallic elements used in magnets, wind turbines, EV motors, and electronics and other modern technologies.

Supply Chain Overview:

- REEs are **mined in several countries**, but **almost all are processed in China**.
- Refining is complex, **energy-intensive**, and **environmentally challenging**, which makes relocation difficult.

REE Overview

Return to World map

Back to Deep Dive Overview

Rare Earth Elements

Why are REE so critical?

Geopolitical Leverage & Export Controls:

- Recent export Controls on REES led to shortage in EU
- The EU and Japan depend heavily on Chinese exports for high-performance magnets used in **EVs, wind turbines, and defense technology**.

Concentration & Environmental Barriers:

China controls the global refining capacity. Refining is energy-intensive and producing waste, few other countries are willing to build such plants.

Even if mining is diversified (USA, Australia, Myanmar), refining bottlenecks remain. **Establishing new facilities takes years and billions of euros**

Back to Deep Dive Overview

What makes a Mineral Critical?
Click here to see

Return to World map

Key Bottlenecks in the Global CRM Supply Chain

Cause: Geographic Concentration & Geopolitical Risk

What does this mean?

A few countries hold **monopolies on production**, creating supply dependencies and vulnerability to political decisions or trade restrictions.

Examplary CRM:

Cobalt
- Democratic Republic of Congo

Cause(s):
- Geographic Concentration
- Monoply on Production
- Politically Unstable
- ESG Risks

Return to Car Overview

Reasons for Criticality & Key Bottlenecks in the Global CRM Supply Chain

Cause: Monopoly on Processing & Refining

What does this mean?

Even when mining is diversified, **refining is often concentrated** in a single country.
Processing is complex, energy-intensive, and costly to relocate.

Examplary CRM:

Rare Earths

- China (>85% of global refining capacity)

Cause(s):

- Monoply on Refining
- Environmental Constraints elsewhere

Return to Car Overview

Reasons for Criticality & Key Bottlenecks in the Global CRM Supply Chain

Cause: Long Lead Times & High Capital Costs

What does this mean?

New mining projects require **immense capital investment** and **take >10 years** to develop, creating a significant lag in supply response to rapidly **growing demand.**

Examplary CRM:

Lithium, Graphite

Origin:
- Democratic Republic of Congo

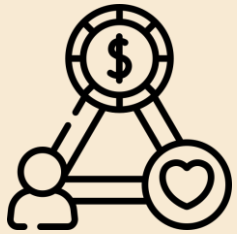
Cause(s):
- Monoply on Production
- Politically Unstable

Return to Car Overview

Reasons for Criticality & Key Bottlenecks in the Global CRM Supply Chain

Cause: Technical, Environmental & Social Challenges

What does this mean?



CRM extraction and processing can have severe environmental impacts (**toxic waste, water use).**

Social conflicts, ESG violations, and permitting delays can halt projects.

Examplary CRM:

Nickel

Origin:
- Indonesia (rapid mining growth, ESG concerns)

Cause(s):
- Environmental damage, social conflict, lack of transparency

Return to Car Overview

What makes a mineral critical?

Currently the **accessible resources** for EV Batteries are **concentrated** in very few countries.

This is a concern for supply chain distribution and could lead **to geopolitical conflicts** similar to oil in the 20th century

Raw Materials and especially critical ones are important for climate neutral Energy & Transport Technologies

A critical raw material is one that is both; economically important and has a high risk of supply disruption.

So how can we ensure secure Supply?

Ensuring secure Supply: The EU- Critical Materials Act

The EU reacted and set up the Critical Raw Materials Act.

Click to learn what this is about!

EU CRM Act: Four Main **Goals**

Diversify CRM Imports to reduce dependencies

Substitute for other Materials

Strengthen own Value Chain

Improve CRM sustainability and circularity

Lesson key takeaways

EU Critical Raw Materials Act

Diversify CRM Imports to Reduce Dependencies

- By 2030, no more than **65%** of any strategic CRM should come from one non-EU country.
- Reduces vulnerability to political instability, trade bans, or conflicts.
- Encourages strategic partnerships with multiple suppliers.

EU to-do:

- Bulid startegic partnerships with ressource rich Countries
- Improve infrastructure for secure transport & logistics
- Monitor dependecy-levels

Example:

•**Today:** 98% of EU's rare earths from China
•**Goal:** Source e.g. from Canada, Australia, Norway and Sweden

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EU Critical Raw Materials Act

Improve CRM sustainability and circularity

- At least **15%** of EU annual consumption from recycling.
- Reduce environmental footprint & dependency on imports.
- Support design for recyclability and advanced recovery tech.

EU to-do:

- **Boost Recycling & Secondary Sourcing:**
- Invest in collection infrastructure for batteries, magnets
- Incentivize urban mining and material recovery

Example:

- **Umicore: large-scale EV battery recycling**
- **Northvolt: “Revolt” project for closed-loop batteries**
- **REMANence: recycling permanent magnets**

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EU Critical Raw Materials Act

Strenghten own Value Chain: From Mine to Market – in the EU

- At least **10% extraction** of own consumption inside the EU.
- At least **40% processing** within the EU.
- **Shorter** and more **resilient supply chains.**

EU to-do:

- **Regulatory & Funding Tools:**
- CRM Action Plan (annual reviews)
- Start critical-material mining projects

Example:

- **Lithium mining projects in Portugal**
- **Processing plants in France & Germany**

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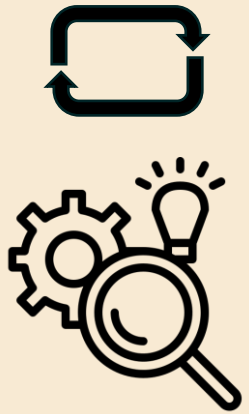
EU Critical Raw Materials Act

Substitute for Other Materials

- Develop and deploy alternative materials to reduce CRM demand.
- Innovation in battery chemistries, magnets, and alloys.
- Lower dependency on high-risk CRMs.



EU to-do:

R&D & Substitution:

- Develop alternative materials
- Improve material efficiency in products

Example:

- **Tesla unfing cobalt-free LFP Batteries in some models**

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What to remember

- Critical Raw Materials are the “new oil” of the 21st century.
- They power the green transition – but supply chains are fragile.
- Geographic & processing monopolies = biggest vulnerabilities.
- The EU wants to diversify, recycle, and strengthen its own value chain.
- Responsible sourcing must balance economy, environment & society.

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Key takeaways

- CRMs are **relevant for everyday technology** and the **green transition**
- A material **becomes critical when it is economically important, and supply is at risk**
- **Supply chains** are **vulnerable due to geographic concentration and limited processing**
- The EU aims to **diversify supply, ramp up recycling and cut dependence on single countries**
- Responsible sourcing must **balance economic, environmental and social factors**

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