



# EU Critical raw materials in the circular economy and strategic value chains and EU R&D funding



*The Periodic Table and us: its history, meaning, and element scarcity*  
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## Periodic Table of the Elements

1 <b>H</b> Hydrogen 1.01																	2 <b>He</b> Helium 4.00
3 <b>Li</b> Lithium 6.94	4 <b>Be</b> Beryllium 9.01											5 <b>B</b> Boron 10.81	6 <b>C</b> Carbon 12.01	7 <b>N</b> Nitrogen 14.01	8 <b>O</b> Oxygen 16.00	9 <b>F</b> Fluorine 19.00	10 <b>Ne</b> Neon 20.18
11 <b>Na</b> Sodium 22.99	12 <b>Mg</b> Magnesium 24.31											13 <b>Al</b> Aluminum 26.98	14 <b>Si</b> Silicon 28.09	15 <b>P</b> Phosphorus 30.97	16 <b>S</b> Sulfur 32.07	17 <b>Cl</b> Chlorine 35.45	18 <b>Ar</b> Argon 39.95
19 <b>K</b> Potassium 39.10	20 <b>Ca</b> Calcium 40.08	21 <b>Sc</b> Scandium 44.96	22 <b>Ti</b> Titanium 47.87	23 <b>V</b> Vanadium 50.94	24 <b>Cr</b> Chromium 51.99	25 <b>Mn</b> Manganese 54.94	26 <b>Fe</b> Iron 55.85	27 <b>Co</b> Cobalt 58.93	28 <b>Ni</b> Nickel 58.69	29 <b>Cu</b> Copper 63.55	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.72	32 <b>Ge</b> Germanium 72.63	33 <b>As</b> Arsenic 74.92	34 <b>Se</b> Selenium 78.97	35 <b>Br</b> Bromine 79.90	36 <b>Kr</b> Krypton 84.80
37 <b>Rb</b> Rubidium 85.47	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.91	40 <b>Zr</b> Zirconium 91.22	41 <b>Nb</b> Niobium 92.91	42 <b>Mo</b> Molybdenum 95.95	43 <b>Tc</b> Technetium 98.91	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.91	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.87	48 <b>Cd</b> Cadmium 112.41	49 <b>In</b> Indium 114.82	50 <b>Sn</b> Tin 118.71	51 <b>Sb</b> Antimony 121.76	52 <b>Te</b> Tellurium 127.6	53 <b>I</b> Iodine 126.90	54 <b>Xe</b> Xenon 131.29
55 <b>Cs</b> Cesium 132.91	56 <b>Ba</b> Barium 137.33	57-71 Lanthanides	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 183.84	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.21	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.22	78 <b>Pt</b> Platinum 195.09	79 <b>Au</b> Gold 196.97	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98	84 <b>Po</b> Polonium [208.98]	85 <b>At</b> Astatine 209.99	86 <b>Rn</b> Radon 222.02
87 <b>Fr</b> Francium 223.02	88 <b>Ra</b> Radium 226.03	89-103 Actinides	104 <b>Rf</b> Rutherfordium [261]	105 <b>Db</b> Dubnium [262]	106 <b>Sg</b> Seaborgium [266]	107 <b>Bh</b> Bohrium [264]	108 <b>Hs</b> Hassium [269]	109 <b>Mt</b> Meitnerium [278]	110 <b>Ds</b> Darmstadtium [281]	111 <b>Rg</b> Roentgenium [280]	112 <b>Cn</b> Copernicium [285]	113 <b>Nh</b> Nihonium [286]	114 <b>Fl</b> Flerovium [289]	115 <b>Mc</b> Moscovium [289]	116 <b>Lv</b> Livermorium [293]	117 <b>Ts</b> Tennessine [294]	118 <b>Og</b> Oganesson [294]

57 <b>La</b> Lanthanum 138.91	58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.91	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium 144.91	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.96	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.93	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93	70 <b>Yb</b> Ytterbium 173.06	71 <b>Lu</b> Lutetium 174.97
89 <b>Ac</b> Actinium 227.03	90 <b>Th</b> Thorium 232.04	91 <b>Pa</b> Protactinium 231.04	92 <b>U</b> Uranium 238.03	93 <b>Np</b> Neptunium 237.05	94 <b>Pu</b> Plutonium 244.06	95 <b>Am</b> Americium 243.06	96 <b>Cm</b> Curium 247.07	97 <b>Bk</b> Berkelium 247.07	98 <b>Cf</b> Californium 251.08	99 <b>Es</b> Einsteinium [254]	100 <b>Fm</b> Fermium 257.10	101 <b>Md</b> Mendelevium 258.1	102 <b>No</b> Nobelium 259.10	103 <b>Lr</b> Lawrencium [262]

- **78 raw materials** evaluated with **fact sheets available, revised methodology** published – CRM website
- Commission's Communication on **2017 list of Critical Raw Materials for the EU**, COM(2017)490, 13.9.2017

2017 CRMs (27)			
Antimony	Fluorspar	*LREEs	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural Rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	*HREEs	*PGMs	Vanadium
Coking coal	Indium	Phosphate rock	

### CRM assessment 2020

- European Commission
- Similar scope and methodology
- Work and consultations in 2019
- Publication in 2020



\*HREEs=heavy rare earth elements, LREEs=light rare earth elements, PGMs=platinum group metals

# Map of CRM ore deposits in Europe

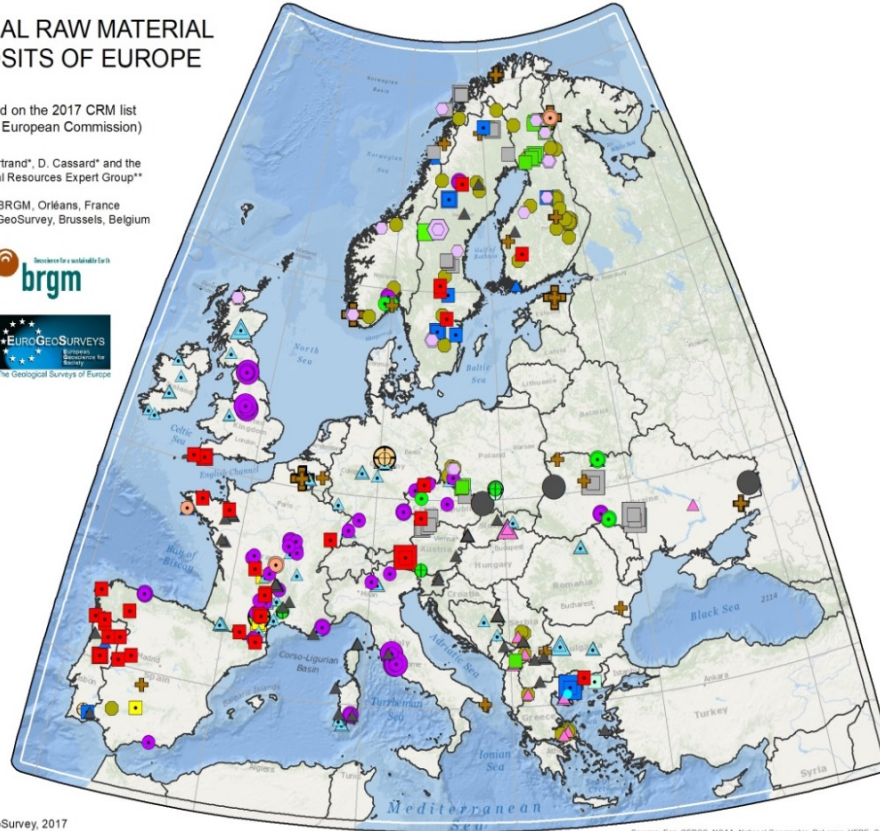


### CRITICAL RAW MATERIAL DEPOSITS OF EUROPE

(based on the 2017 CRM list of the European Commission)

G. Bertrand\*, D. Cassard\* and the Mineral Resources Expert Group\*\*

\* BRGM, Orléans, France  
\*\* EuroGeoSurvey, Brussels, Belgium



### Legend

#### Commodity

- Beryllium (BeO)
- Bismuth (metal)
- Borates (B2O3)
- Baryte (BaSO4)
- Cobalt (metal)
- Coking coal
- Fluorite (CaF2)
- Gallium (metal)
- Germanium (metal)
- Graphite
- Hafnium (metal)
- Indium (metal)
- Magnesite, magnesium (MgCO3)
- Niobium - columbium (Nb2O5)
- Phosphate (P2O5)
- Rare earths elements (RE2O3)
- Platinum, platinumoids group metals
- Antimony (metal)
- Scandium (metal)
- Tantalum (Ta2O5)
- Vanadium (metal)
- Wolfram (WO3)

#### Deposit size

- Class A (super-large)
- Class B (large)
- Class C (medium)

© BRGM, EuroGeoSurvey, 2017

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors



Revised methodology, based on criteria, priority data and information over the last 5 years, thresholds, comparability resulting in a single list

### Economic importance

- Importance of a raw material per economic sector & importance of the sector in the EU economy (value added)
- Substitution (technical and cost performance)

### Supply risk

- Global supply and EU sourcing (ores/refined materials)
- Market concentration (HHI)
- Governance performance (WGI)
- Import reliance
- Trade agreements and restrictions
- Substitution (production, criticality, co/by-production)
- End-of-Life Recycling Input Rate

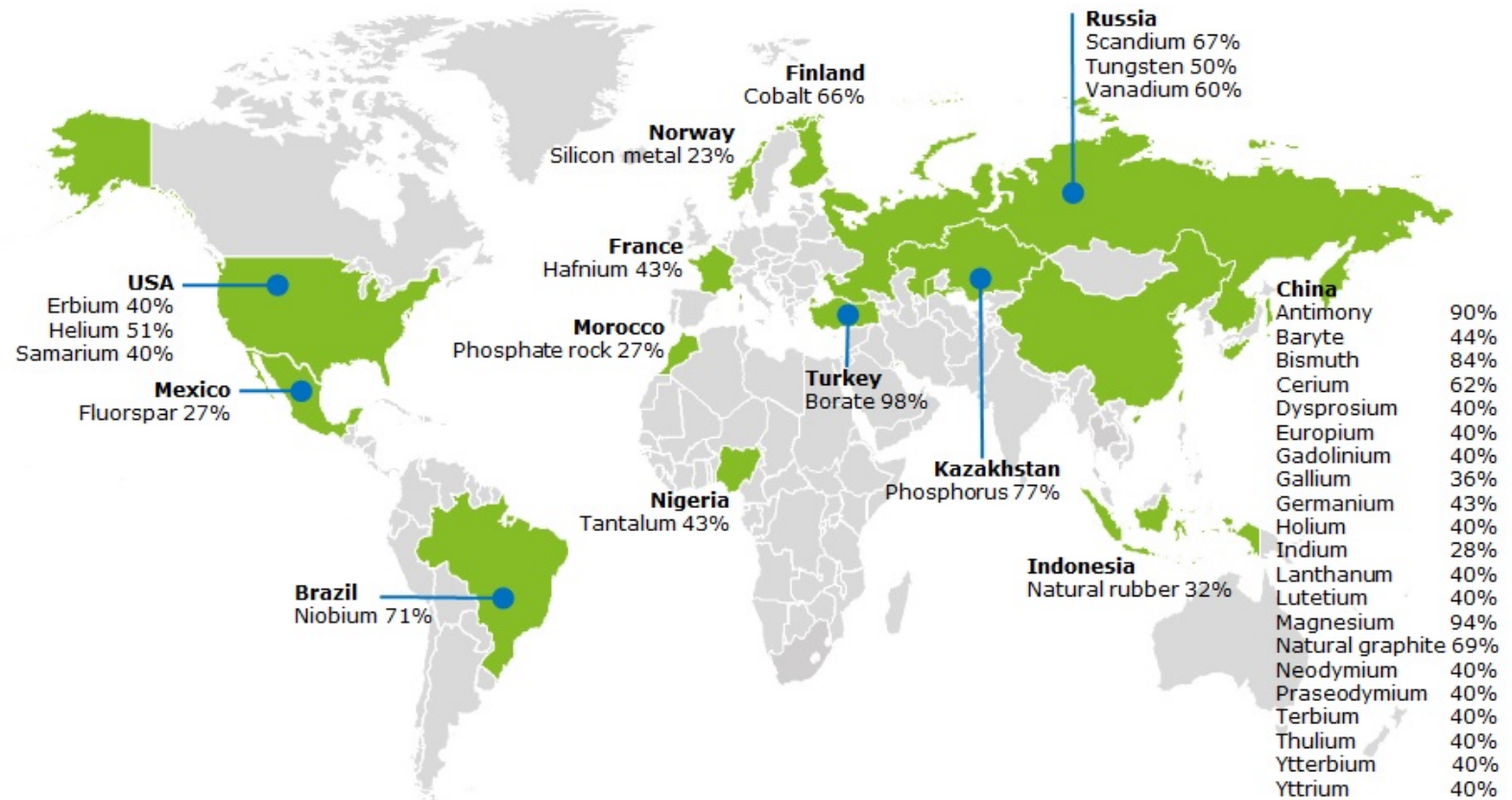




# Biggest suppliers of CRM to the EU



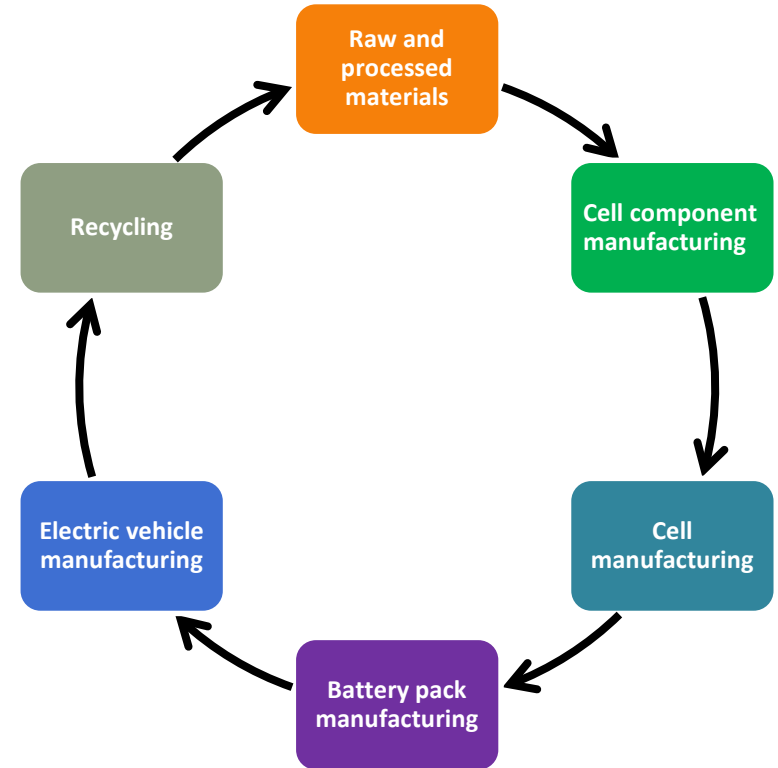
# Raw Materials Initiative EU Critical Raw Materials



## Batteries – example of the strategic EU industrial value chains

The objective is:

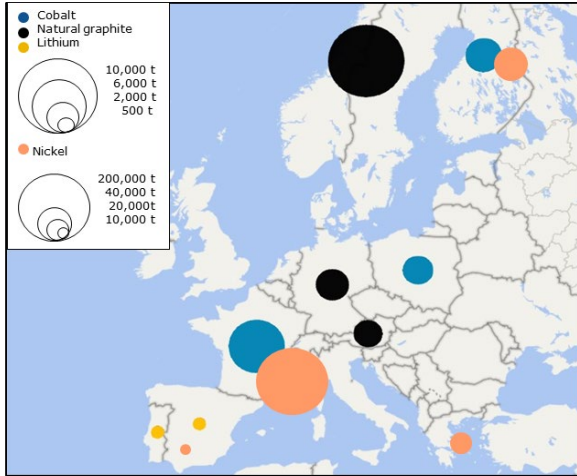
- To create a competitive manufacturing value chain in Europe with sustainable battery cells at its core .
  - To capture a battery market of up to €250 billion a year from 2025 onwards. Covering the EU demand alone requires at least 10 to 20 'gigafactories' (large-scale battery cell production facilities).
- Raw and processed materials:
- cobalt, lithium, natural graphite, nickel; but also manganese, silicon metal,



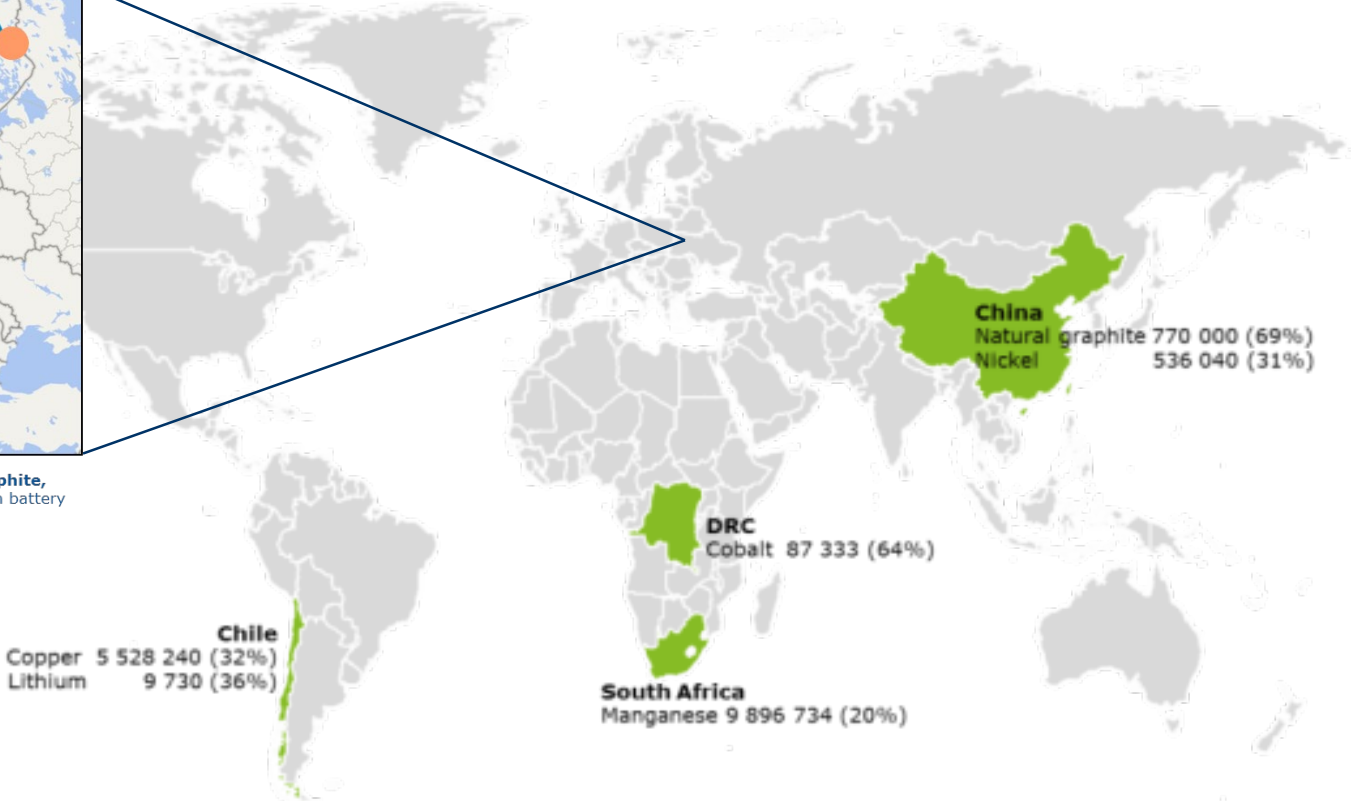
# Global and EU production of battery materials



## Raw Materials Initiative EU Critical Raw Materials



Mining production in Europe: cobalt, lithium, natural graphite, nickel; metallic content, tonnes (2016) (Source: Survey on battery raw materials RMSG, 2018)







End-of-life recycling input rate (EOL-RIR) [%]

																Legend																			
																> 50%	> 25-50%	> 10-25%	1-10%	< 1%															
H															He																				
Li	Be															B*	C	N	O	F*	Ne														
0%	0%															0.6%				1%															
Na	Mg															Al	Si	P*	S	Cl	Ar														
	13%															12%	0%	17%	5%																
K*	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																		
0%		0%	19%	44%	21%	12%	24%	35%	34%	55%	31%	0%	2%		1%																				
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																		
		31%		0%	30%		11%	9%	9%	55%		0%	32%	28%	1%																				
Cs	Ba	La-Lu <sup>1</sup>	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																		
	1%		1%	1%	42%	50%		14%	11%	20%			75%	1%																					
Fr	Ra	Ac-Lr <sup>2</sup>	Rf	Db	Sg	BK	Ks	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo																		

<sup>1</sup> Group of Lanthanide	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu														
	1%	1%	10%	1%		1%	38%	1%	22%	0%	1%	0%	1%	1%	1%														
<sup>2</sup> Group of Actinide	Ac	Th	Pa	U	Np	Am	Cm	Bk	Cf	Es	Fm	Md	No	No	Lr														

Aggregates	Bentonite	Coaking Coal	Diatomite	Feldspar	Gypsum	Kaolin Clay	Limestone	Magnesite	Natural Cork	Natural Graphite	Natural Rubber	Natural Teak Wood	Perlite	Sapele wood	Silica Sand	Talc														
7%	50%	0%	0%	10%	1%	0%	58%	2%	8%	3%	1%	0%	42%	15%	0%	5%														

JRC elaboration based on the EU list of Critical Raw Materials (2017) and MSA Study (2015)

\* F = Fluorspar; P = Phosphate rock; K = Potash, Si = Silicon metal, B= Borates.



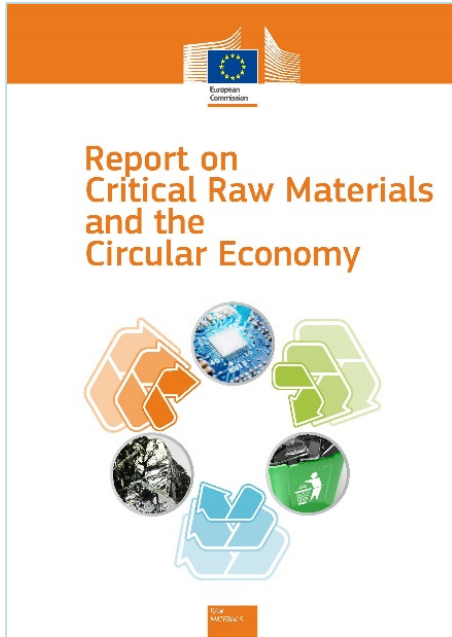
### Objectives:

- To help EU Member States implement the new provisions on critical raw materials in the EU Waste Framework Directive
- Provide information, data sources and identify best practices and possible further actions

Issued in January 2018 (SWD(2018)36), taking into account the 2017 list of 27 critical raw materials

### Key Sectors:

- Electric and Electronic Equipment
- Automotive
- Batteries
- Renewable Energy
- Defense equipment
- Chemicals & Fertilizers





## Societal Challenge 5 call - "Greening the economy in line with the Sustainable Development Goals (SDGs)"

Major Issue Areas for Mining and the SDGs



- ✓ €240 million available under SC5 (plus FTI, SME Instrument)
- ✓ 2/3 of the budget for Innovation Actions (TRL 6-7)
- ✓ Specific attention to CRMs, Circular economy, Production, Substitution...
- ✓ Feed into EU Raw Materials Information System – RMIS
- ✓ "Bridge" to Post-2020 "FP9"



CE-SC5-07-2018-2019-2020: Raw materials innovation for the circular economy: sustainable processing, reuse, recycling and recovery schemes (IA)

- a) Sustainable processing and refining of primary and/or secondary raw materials
- b) Recycling of raw materials from end-of-life products
- c) Recycling of raw materials from buildings
- d) Advanced sorting systems for high-performance recycling of complex end-of-life products

CE-SC5-08-2019: Raw materials policy support actions for the circular economy (CSA)

- c) Responsible sourcing of raw materials in global value chains

SC5-09-2019: New solutions for the sustainable production of raw materials (RIA)

- b) Digital mine
- c) Recovery of metals and minerals from sea resources (processing)

SC5-10-2019: Raw materials innovation actions: exploration and Earth observation in support of sustainable mining (IA)

- b) Integrated exploration solutions
- c) Services and products for the extractive industries life cycle

- **Budget: over** €80 million
- **Deadlines: 19 February 2019** (CSA and First stage of RIA, IA); and 4 Sep 2019 (Second stage of RIA, IA)



## Commission proposal for a € 100 billion R&I funding programme (2021-2027)

- Digital and Industry: €15 billion (Circular Industries (incl. “Raw Materials”), Low-Carbon and Clean Industries)







**Large part of the periodic table will be crucial for the strategic value chains**

**Responsible and sustainable sourcing is key for Resource security**

**High tech metals will become oil and gas of tomorrow**

# Thank you!



## **Critical raw materials for the EU:**

[http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical\\_en](http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en)

## **Methodology for establishing the EU list of critical raw materials:**

<https://publications.europa.eu/en/publication-detail/-/publication/2d43b7e2-66ac-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-32064602>

## **Report on critical raw materials and the circular economy :**

<https://publications.europa.eu/en/publication-detail/-/publication/d1be1b43-e18f-11e8-b690-01aa75ed71a1>

## **Raw Materials Information System:**

<http://rmis.jrc.ec.europa.eu/>

## **EU Raw materials, metals, minerals and forest-based industries:**

[https://ec.europa.eu/growth/sectors/raw-materials\\_en](https://ec.europa.eu/growth/sectors/raw-materials_en)

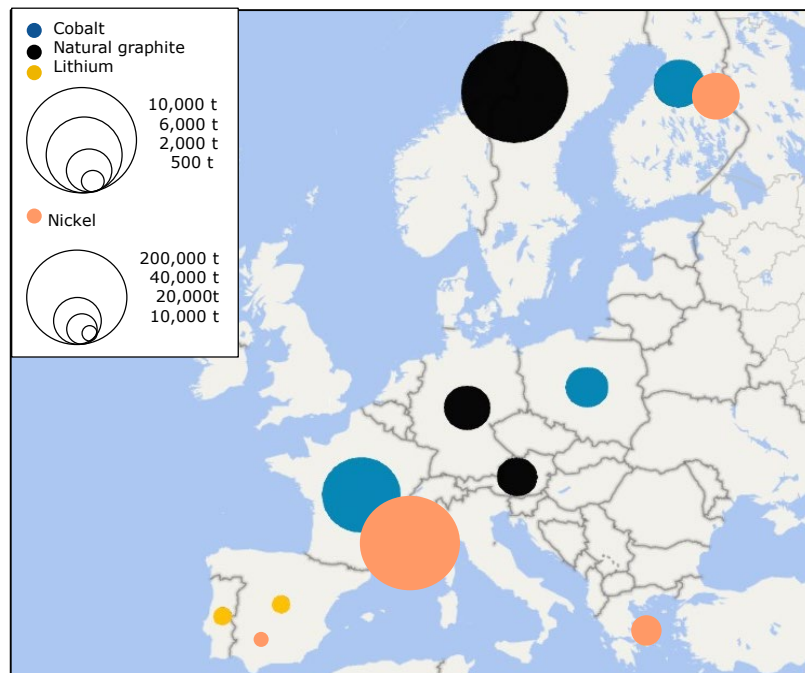
## **EIP on Raw Materials:**

<https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en>

## **Horizon 2020 - raw materials and calls:**

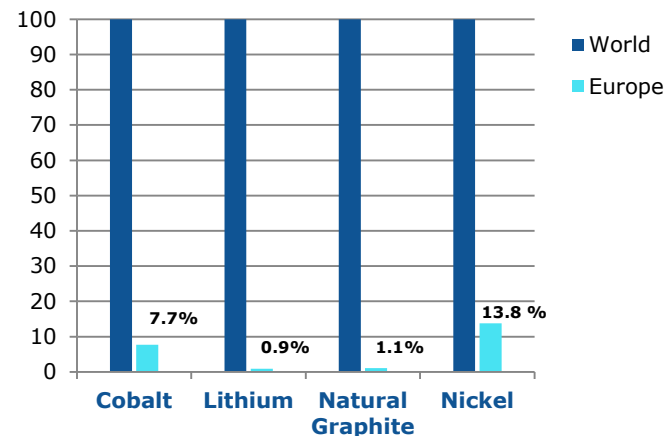
<https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/index.html>

# Back up slides



**Mining production in Europe: cobalt, lithium, natural graphite, nickel; metallic content, tonnes (2016)** (Source: Survey on battery raw materials RMSG, 2018)

**Cobalt:** 9,698 t (7.7%)  
**Lithium:** 322 t (0.9%)  
**Natural graphite:** 12,650 t (1.1%)  
**Nickel:** 270,126 t (13.8%)



**Figure 2 – World share of European production (2016)**  
 (Source: Survey Member States- RMSG, 2018)

# Exploration activities



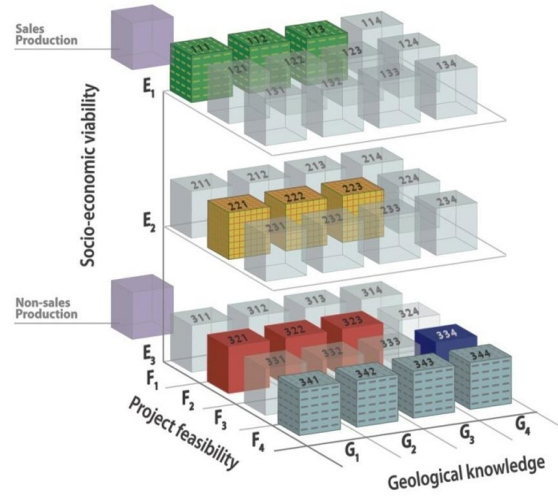
# Mobility package Action Plan on Batteries



UNFC classification	Commercial projects (E1;F1; G1,2,3) <sup>1</sup>	Potentially commercial projects (E2;F2;G1,2,3) <sup>1</sup>	Non-Commercial projects (E3;F2;G1,2,3) <sup>1</sup>	Exploration projects (E3;F3;G4) <sup>1</sup>
<b>Cobalt</b>	--	<b>Total 3 SE(3)</b>	10 ES(1), FI(5), SE(4)	25 AT(2), CY(3), CZ(1), ES(7), FI(1), IE(1), NO(1), PL(1), SE(5), SK(2), UK(1)
<b>Lithium</b>	<b>Total 3 FI(1),PT(2)</b>	<b>Total 7 AT (1), CZ(1), DE(1), ES(1), FI(1), PT(2)</b>	3 AT(1), ES(1), UK(1)	16 (40) <sup>2</sup> CZ(1), DE(2), ES(2), FI(1), FR(2), GR(1), IE(3), NO(1) SE(3), PT(40) <sup>2</sup>
<b>Natural graphite</b>	<b>Total 1 SE (1)</b>	<b>Total 2 SE(1), SK (1)</b>	2 SE(2)	28 CZ(3), DE(1), FI(10), ES(4), SE(2) NO(8)
<b>Nickel</b>	--	<b>Total 3 SE(3)</b>	6 FI(3),SE(1), UK(2)	21 AT(2), CY(3), DE(1), ES(5), FI (4), LV(1), SK(2), SE(3)

Note 1 – UNFC, Definition of categories (see United Nations Framework Classification (ECE ENERGY SERIES No. 42):  
 E axis: E1, extraction and sale has been confirmed to be economically viable; E2, expected to become economically viable; E3, not expected to become economically viable or evaluation is at too early a stage.  
 F axis: F1, feasibility of extraction by a development project or mining operation has been confirmed; F2, feasibility is subject to further evaluation; F3, feasibility cannot be evaluated due to limited technical data.  
 G axis: G1, quantities associated with a known deposit that can be estimated with a high level of confidence (G1), moderate level of confidence (G2), a low level of confidence (G3)

Note 2 – 40 applications for lithium exploration have been submitted; 12 blocks have been defined for lithium exploration in the Centre and North of Portugal. Public tenders are going to be launched in 2018.



**Project categories, exploration (UNFC-2009)**  
 (Source: Survey Member States- RMSG, 2018)







## Commercial projects

### **Lithium** (reserves)

- Alvarrões, Mina do Barroso (PT): 38,940 t
- Keliber (FI): 35,750 t

## Potentially commercial projects

### **Lithium** (resources;(reserves))

- Alvarrões, Mina do Barroso: 79,110 t
- Argemela, Sepeda (PT): 89,810 t
- Cinovec (CZ): 1,285,790 t
- Keliber (FI): 50,970 t
- San Jose (ES): 313,860 t
- Wolfsberg: 51,160 t
- Zinnwald (DE): 132,740 t

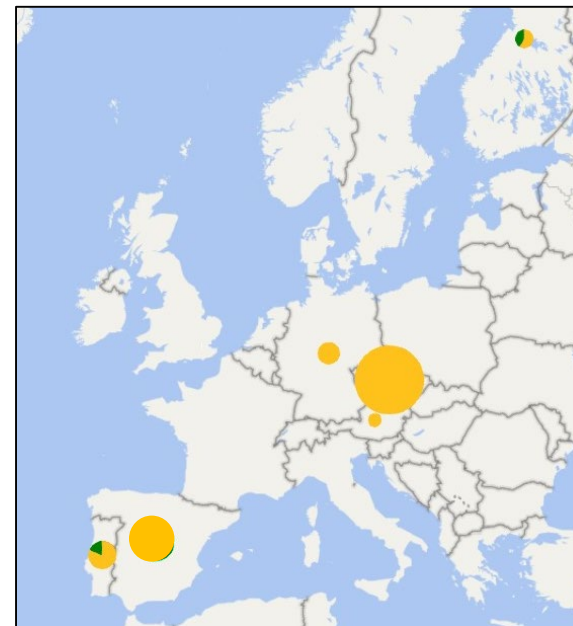
## Non-commercial projects

- Co (10); Li (3); Graphite (2);Ni (21)

## Exploration projects

- Co (10); Li (3); Graphite (2);Ni (21)

## Lithium projects



**Figure 5 – Lithium potentially commercial projects (2016)**  
(Source: Survey on battery raw materials - RMSG, 2018)