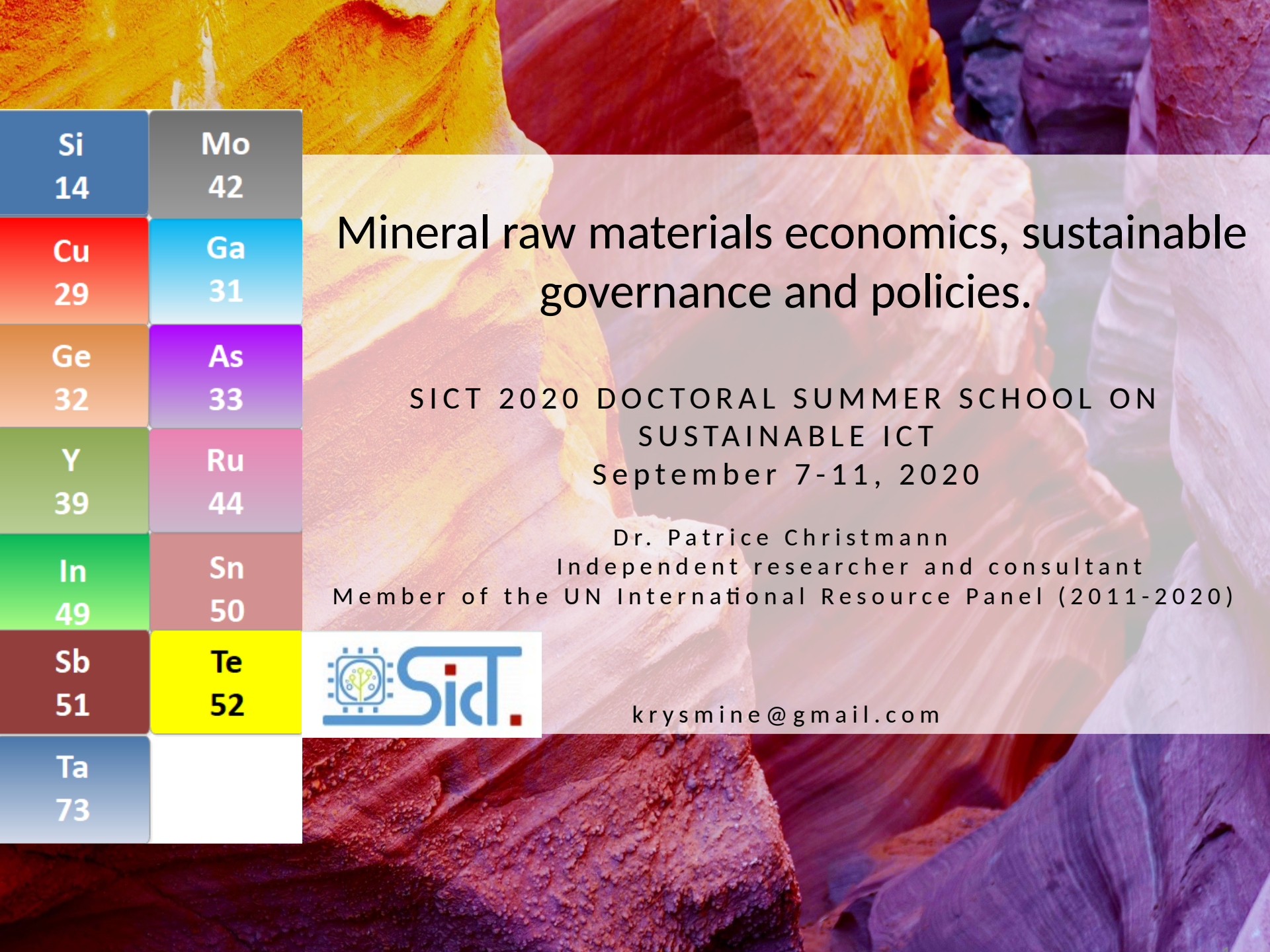

Mineral raw materials economics, sustainable governance and policies.

SICT 2020 DOCTORAL SUMMER SCHOOL ON SUSTAINABLE ICT
September 7-11, 2020

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Minerals and metals:
a (very) few economic aspects

- Minerals and/or metals are essential inputs for thousands of supply chains « modern » lifestyles depend, and thus the global economy on
- If you can’t grow it, you need to mine it
- … and then, to sustainably use it

ELEMENTS (MOSTLY METALLIC ELEMENTS) IN INDUSTRIAL SCALE USE FOR ENERGY RELATED APPLICATIONS. Author: P. Christmann (unpublished in English, published in French, this being an updated version November 2019)

H																He
Li	Be										B	C	N	O	F	Ne
Na	Mg										Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh		Uuo

Lanthanides	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Hm	Er	Tm	Yb	Lu
(Rare Earth) Actinides	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

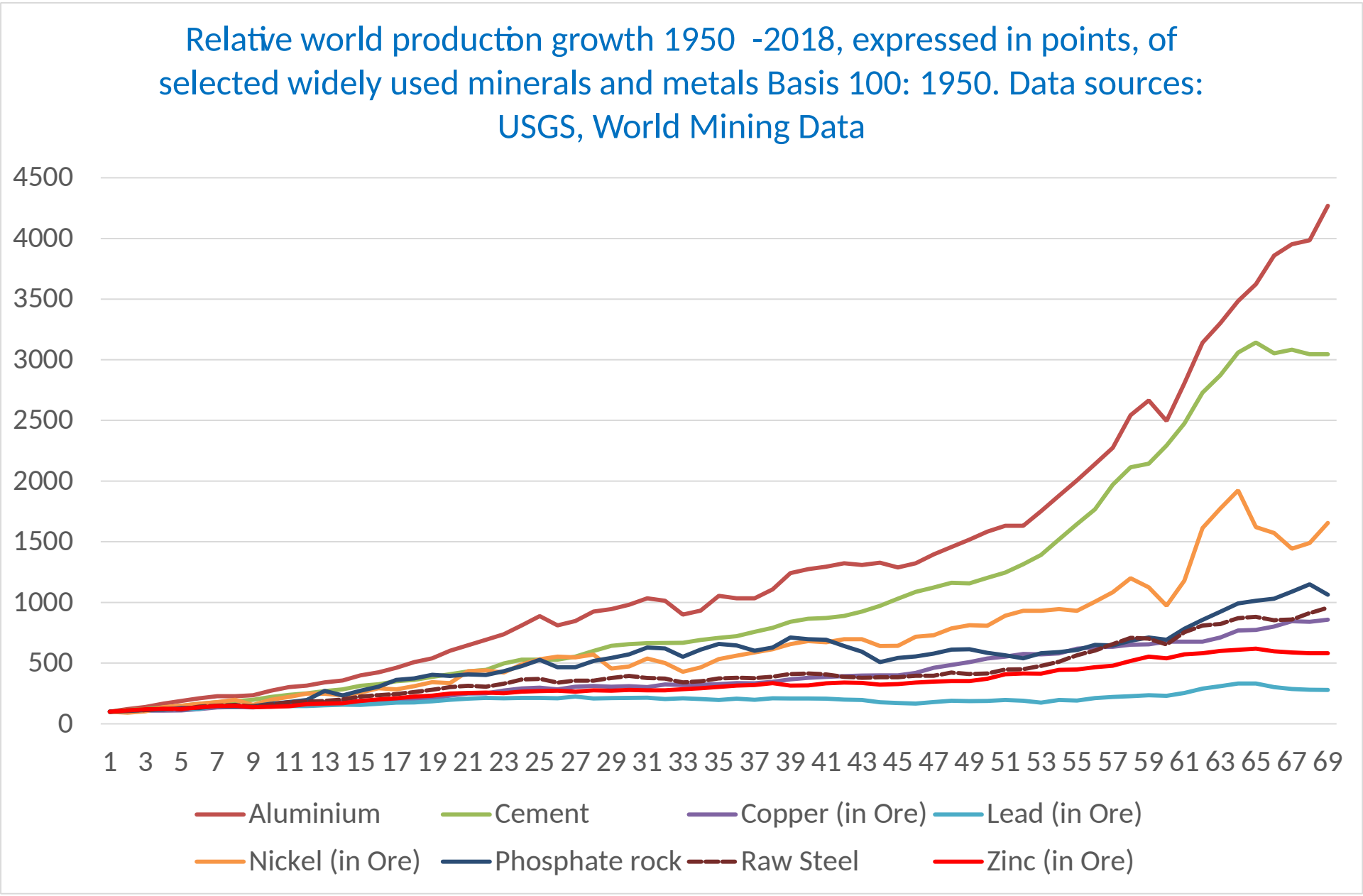
Energy storage
Connectivity
Energy saving
Catalysis (fuel cells)

Electricity generation and transport
Elements specific to nuclear electricity generation

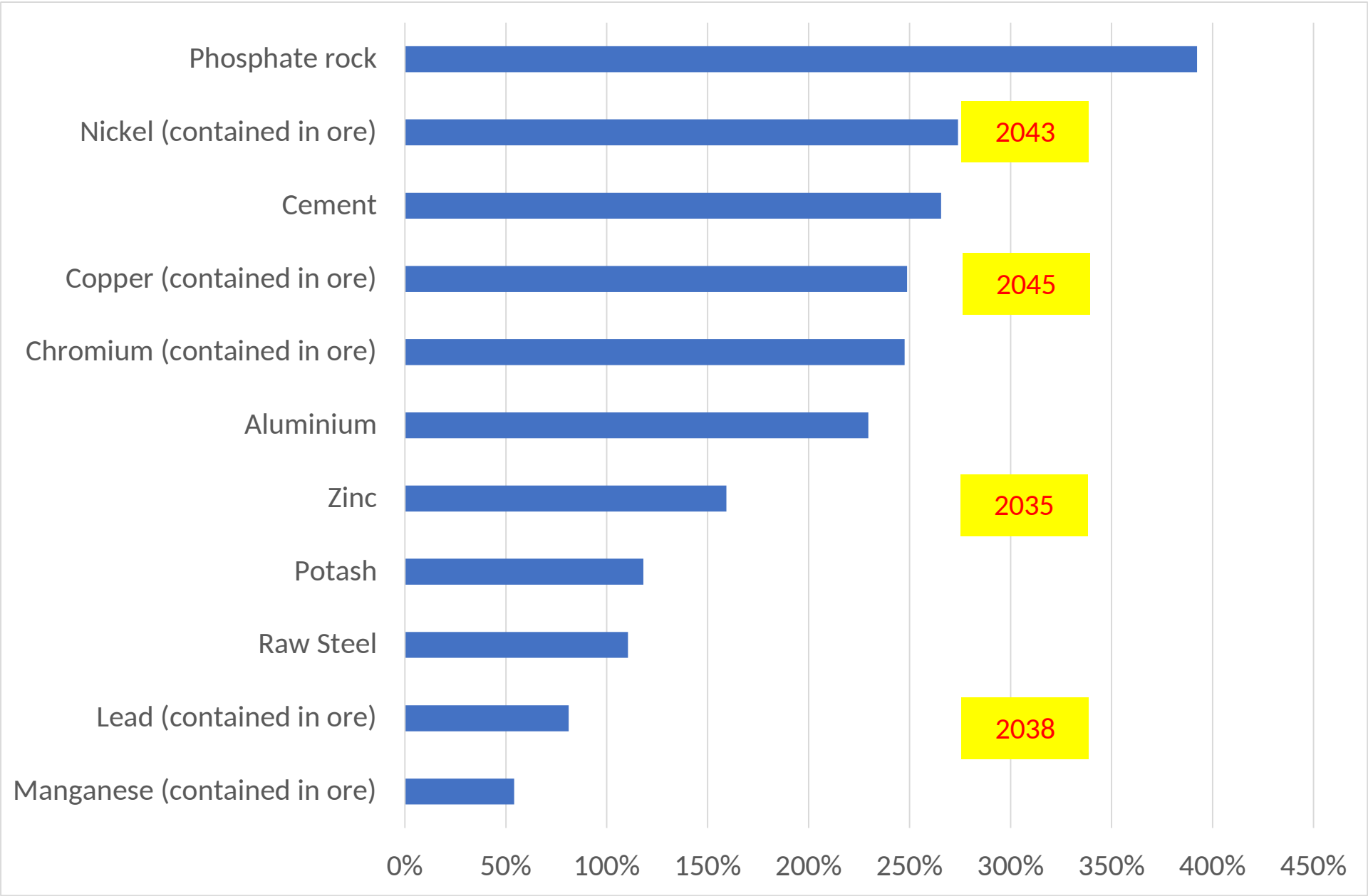
Photovoltaics

Permanent magnets for windmills and electrical/ hybrid cars

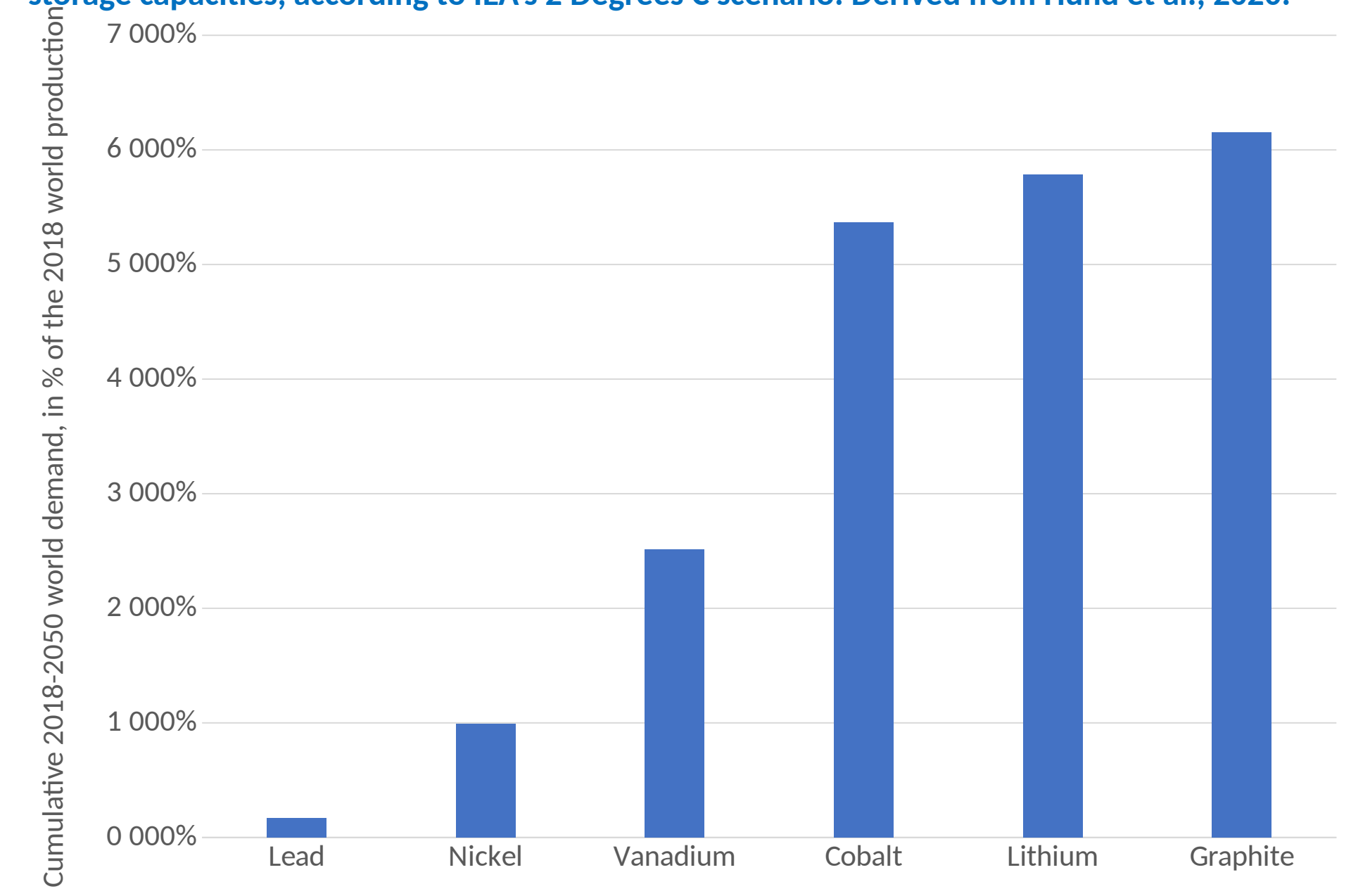
Lighting
Supraconductors
Oil and gas drilling muds


Relative world production growth 1950 -2018, expressed in points, of selected widely used minerals and metals Basis 100: 1950. Data sources: USGS, World Mining Data
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69
Aluminium
Cement
Copper (in Ore)
Lead (in Ore)
Nickel (in Ore)
Phosphate rock
Raw Steel
Zinc (in Ore)

Anticipated world production growth (low scenario) 2018-2050 of selected high-volume produced minerals and metals, and year of current static reserves exhaustion



Cumulative production, from 2018 to 2050, expressed as percentages of the 2018 world production, of mineral raw materials that would be needed for the production of electricity storage capacities, according to IEA's 2 Degrees C scenario. Derived from Hund et al., 2020.



Production depends on a number of factors:

- Geological resources
- Successful exploration
- Investment in exploration and in the development of new mines, ore processing, smelters and refineries
- Where needed, investment in infrastructure
- Availability of skills
- Access to the needed technologies
- Social acceptance
- Lowest technically possible environmental impacts

Some figures:

- 10 to 20 billion US$ are invested annually in exploration.
- The AVERAGE capital expenditure required to commission a new mine is about 500 M$. It can take over 10 Bn $ to commission a top-sized mine
- Investors will not be very interested by projects that use less than 8% as a discounting factor for future cash flows, generate less than 30% return on investment and have a long pay back period (more than +/- 5 years)
- Project related data can be found by Googling, for instance « copper + feasibility study + NI 43-101 ». You will be able to read full feasibility studies (a few hundred pages each).
- Investment in mining is highly risky.

Sustainability issues in a nutshell

Key sustainability issues related to minerals and metals production:

- 16% of the world's CO2 emissions. Trend: growing. Main sources: aluminium, cement and steel production. Figures for individual raw materials and projects are very variable. They dépend on the material(s) produced, the processes and the energy mix used (coal being the absolute worst source of energy).

- About 90 bn t of raw materials are extracted annually + overburden + waste rock.

- Generation of massive amounts of waste, especially ore processing tailings, some can become a source of harmful releases of toxic metallic compounds

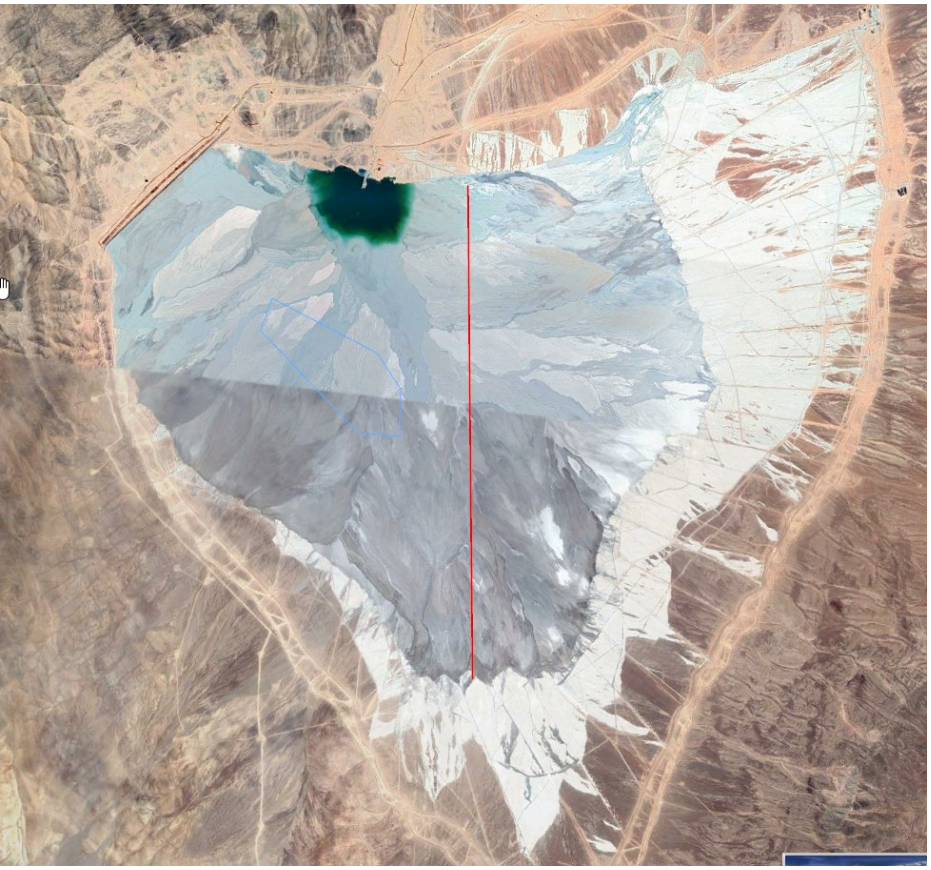


Image: ©Google Earth

This is the tailings pond of Mina La Escondida (Chile), the world largest copper mine (about 5% of the world copper production, or 1.1 Mt Cu (2019), come from this mine.

The red line is 6 km long.

With an average of 0.7% Cu in the orem La Escondida generates about 150 Mt waste/ year.

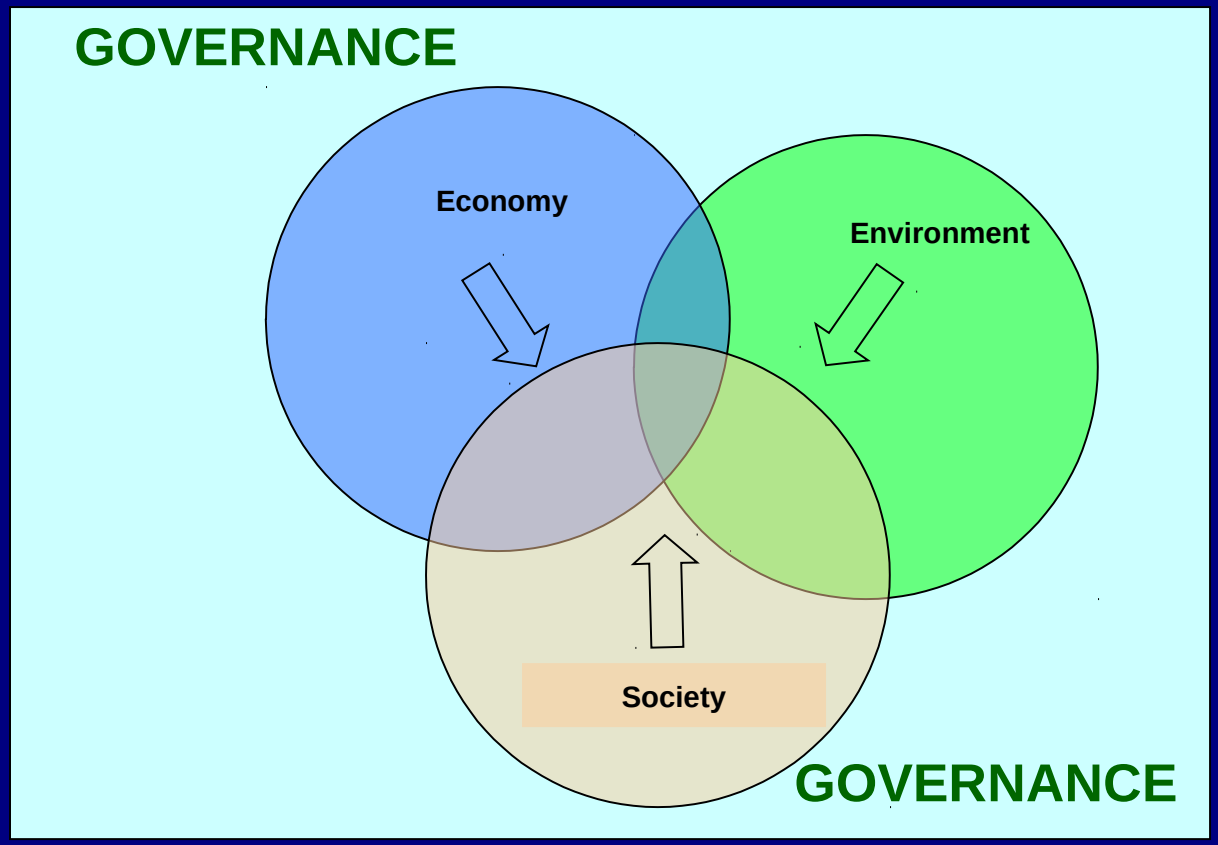
In absence of other economic uses this waste will have to be safely stored for ever.

About 150 major tailing dams failures, some deadly, were recorded since 1960.

EU and International resources Governance: a must, but still in its infancy.

GOVERNANCE IS THE FOUTH DIMENSION, AND THE DRIVER OF SUSTAINABLE DEVELOPMENT. IT HAS MULTIPLE COMPONENTS

Local, regional, national, multinational scales



Data > Information > Knowledge > Expertise inform Policies, Voluntary Initiatives, Management and Operational Practices, Regulations, Public Reporting, Evaluations, Education, Research and Innovation, Technological Choices

EU Minerals and Metals Resources Governance issues:

- EU is highly dependent on imports, especially minerals and metals. It is very exposed to supply issues as it's imports are widely dependent form countries (China and some others) with a very poor environmental/ social/ governance track record.
- EU has no legal basis to develop its own minerals and metals policy and regulations. But in can act in several relevant domains: environment, development cooperation, research and innovation (it does, mostly since 2014), trade.
- There is no EU minerals and metals governance framework, only some limited guidelines.
- On September 3rd the Commission published its 10 points Critical Raw Materials Action Plan [COM(2020) 474]. It remains to be seen how it will translate in specific, funded, actions.

ACTIONS FORESEEN IN THE EU CRITICAL RAW MATERIALS ACTION PLAN COM(2020) 474 6 03/09/2020

	Action	Dates/ Time span
1	Establishment a European Raw Materials Alliance, initially to build resilience and open strategic autonomy for the rare earths and magnets value chain, before extending to other raw material areas	2020-2027
2	Develop sustainable financing criteria for the mining, extractive and processing sectors by the end of 2021	2021
3	Launch critical raw materials research and innovation in 2021 on waste processing, advanced materials and substitution	2021-2027
4	Map the potential of secondary critical raw materials from EU stocks and wastes to identify viable recovery projects by 2022.	2022
5	Identify mining and processing projects and investment needs and related financing opportunities for critical raw materials in the EU that can be operational by 2025, with priority for coal-mining regions	2025
6	Develop expertise and skills in mining, extraction and processing technologies, as part of a balanced transition strategy in regions in transition from 2022 onwards (Commission, industry, trade unions, Member States and regions);	2021-2027
7	Deploy Earth-observation programmes and remote sensing for resource exploration, operations and post-closure environmental management (Commission, industry);	2021-2027
8	Develop Horizon Europe R&I projects on processes for exploitation and processing of critical raw materials to reduce environmental impacts starting in 2021	2021-2027
9	Develop strategic international partnerships and associated funding to secure a diversified and sustainable supply of critical raw materials, including through undistorted trade and investment conditions, starting with pilot partnerships with Canada, interested countries in Africa and the EU's neighbourhood in 2021.	2021-2027
10	Promote responsible mining practices for critical raw materials through the EU regulatory framework (proposals in 2020-2021) and relevant international cooperation32 (Commission, Member States, industry, civil society organisations);	2020-2027

UNSUSTAINABLE PRODUCT AND SERVICES PURCHASING CRITERIA

- Functions
- Looks
- Service
- Price (Beware of the hidden costs!)

SUSTAINABLE PRODUCT AND SERVICES PURCHASING CRITERIA

- Production conditions (environmental and social footprint)
- Functions
- Looks
- Service
- Maintainability
- Re-usability (at least of some components)
- Recyclability

- Price

TRANSPARENCY AND QUADRUPLE BOTTOMLINE ACCOUNTABILITY ARE KEY TO SUSTAINABLE DEVELOPMENT

A detailed internationally peer-reviewed assessment of the global mineral resources governance landscape was published this year by the United Nations International Resource Panel (300 p. +, extensive bibliography):

https://resourcepanel.org/reports/mineral-resource-governance-21st-century

Thank you for your attention and for the invitation