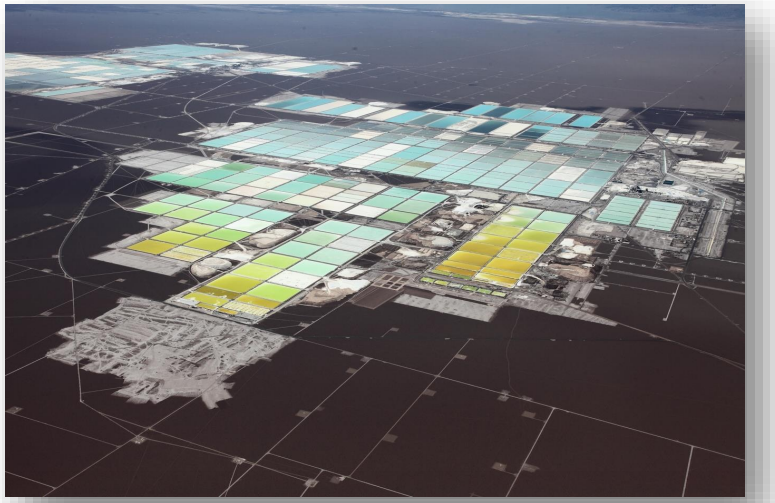

KIVI symposium 'Een beter milieu begint bij grondstoffen en materialen', Enschede, October 12, 2021

Zijn de grondstoffen voor de energie transitie (en mobiliteits transitie) schaars ?

Dr. Arjan Dijkstra

ITC | Faculty of Geo-information Science & Earth Observation, Universiteit Twente

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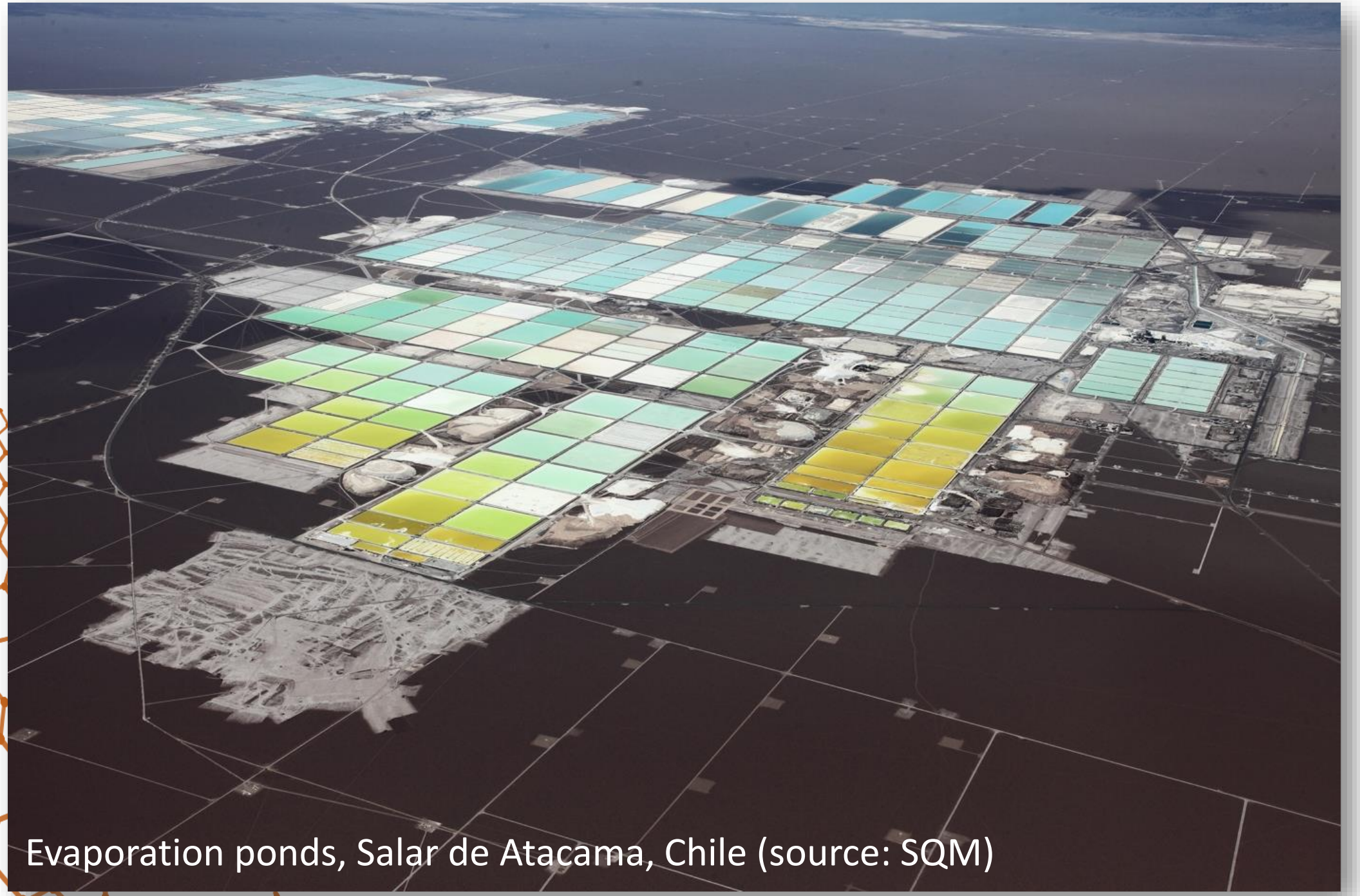

Evaporation ponds, Salar de Atacama, Chile (source: SQM)

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Chile:
c. 20 KT Li / yr
25% of world production
c. 2 million Tesla S's or 7 million Nissan Leafs

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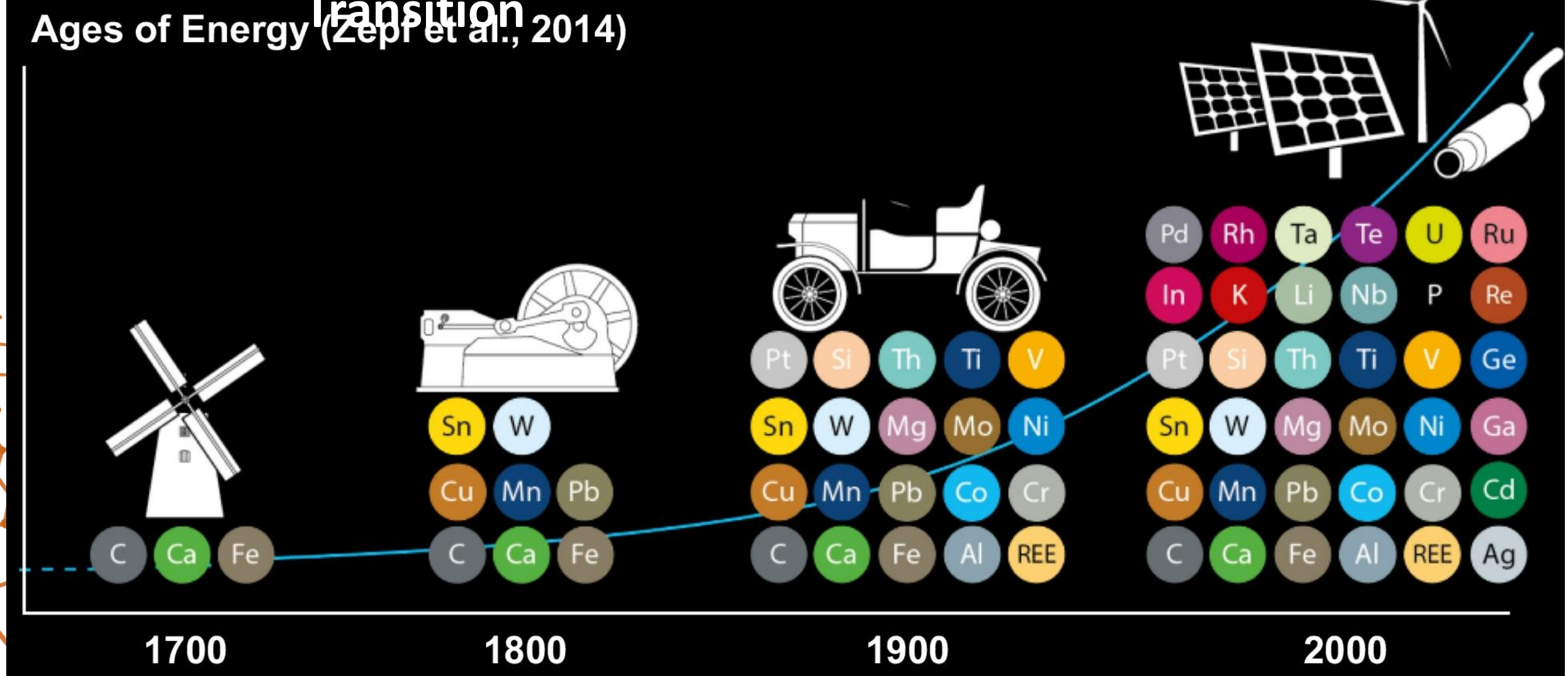
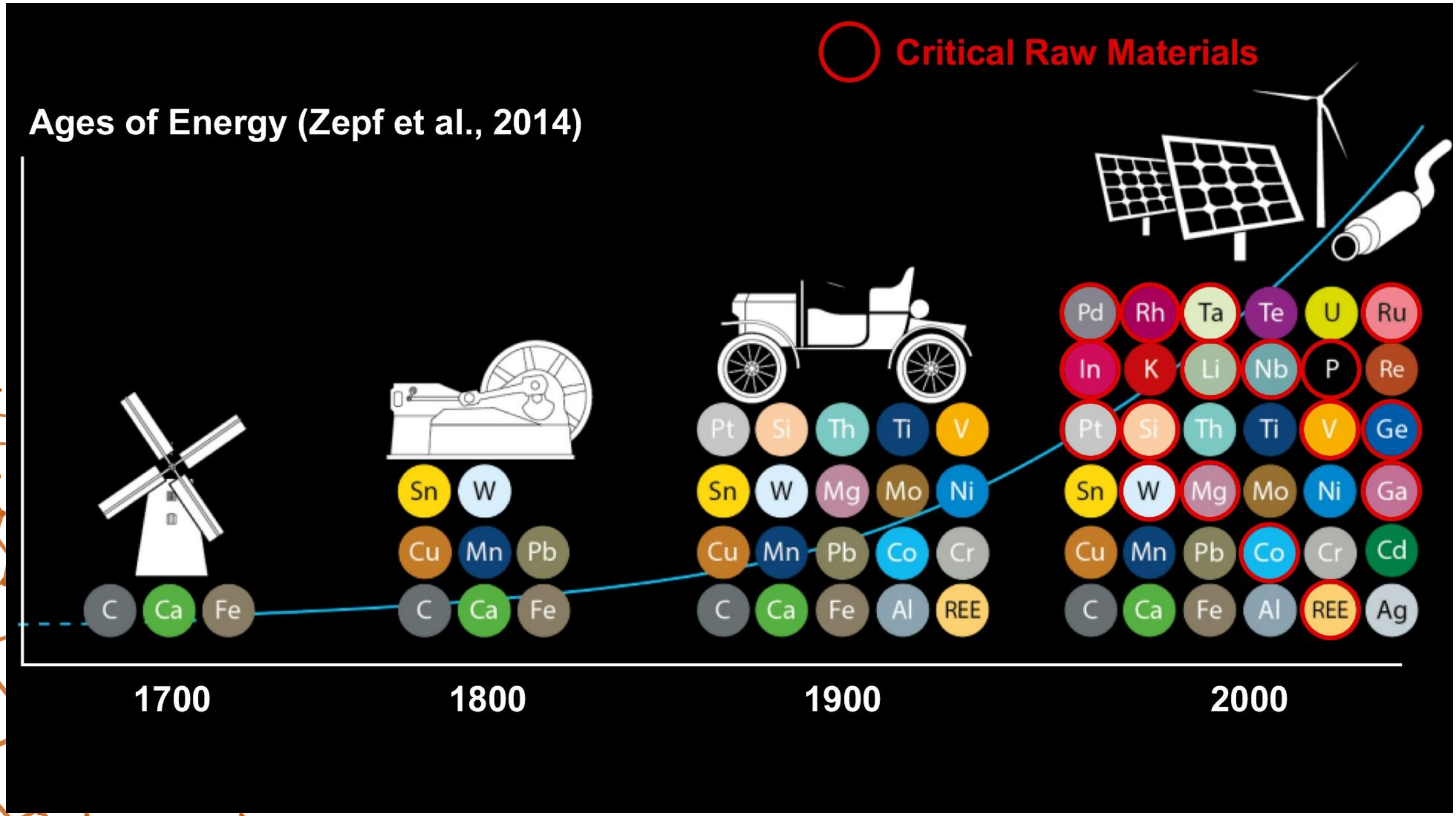
The Energy Transition is also a Materials Transition



'The green stone-age'


Critical Raw Materials
Ages of Energy (Zepf et al., 2014)
C Ca Fe
Sn W Cu Mn Pb C Ca Fe
Pt Si Th Ti V Sn W Mg Mo Ni Cu Mn Pb Co Cr C Ca Fe Al REE
Pd Rh Ta Te U Ru In K Li Nb P Re Pt Si Th Ti V Ge Sn W Mg Mo Ni Ga Cu Mn Pb Co Cr Cd C Ca Fe Al REE Ag
1700
1800
1900
2000

CONFLICT

Co

Sn

Ta

W

Au

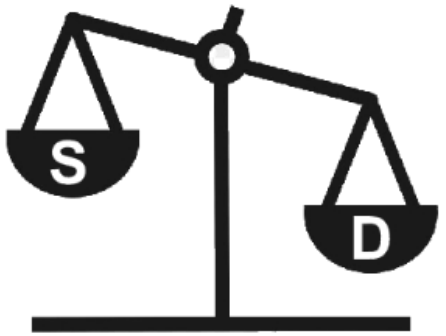
MONOPOLY

Rare Earth Elements (REE)

Nd Pr

Dy Yb

HIGH DEMAND



C as graphite

Li

Co

In

V

RUNNING OUT?

In

Sb

P

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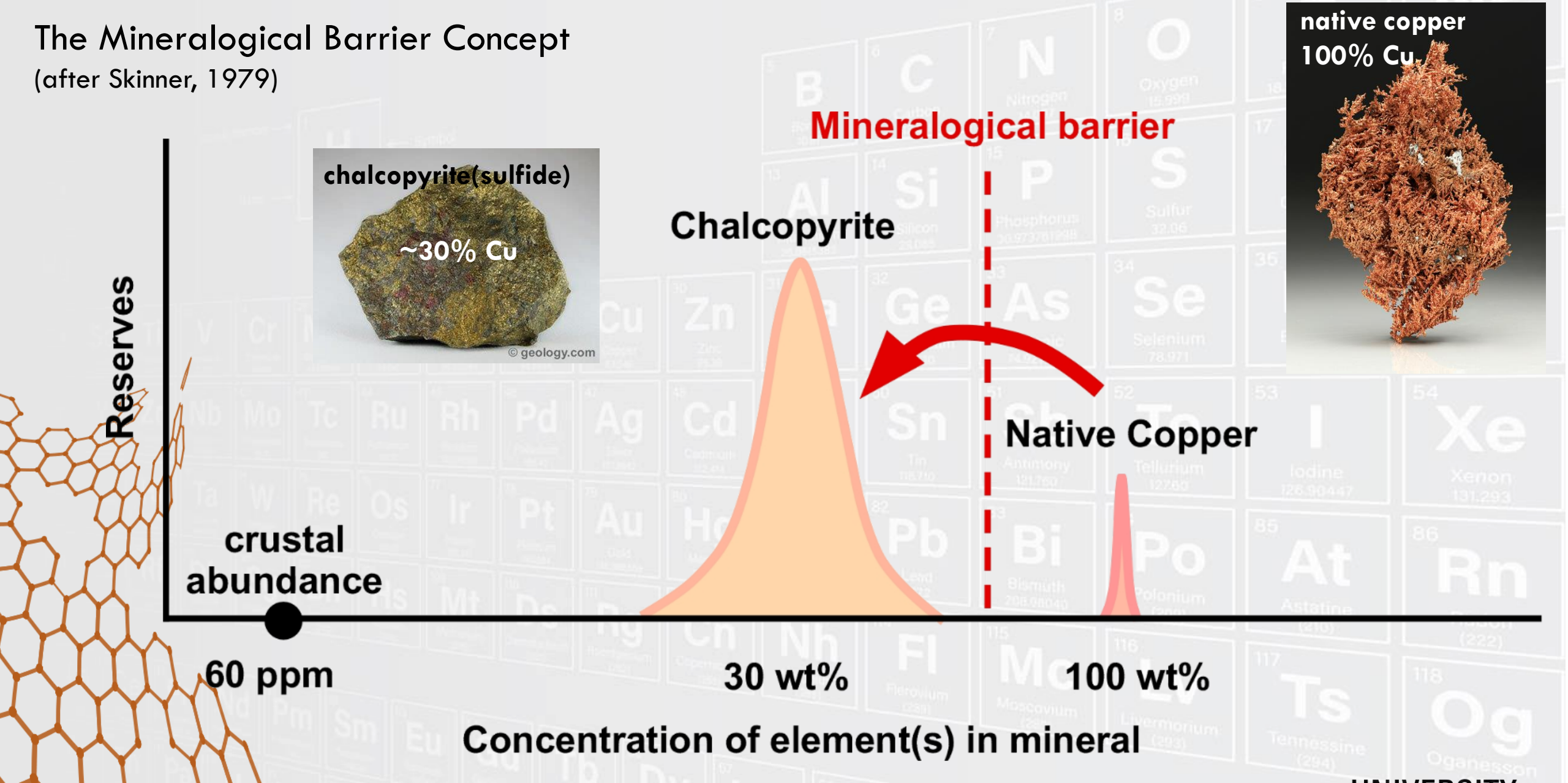
Nebra Sky Disk and associated items
c. 1600 BC, Nebra, Germany
Landesmuseum für Vorgeschichte, Halle, Saxony-Anhalt

Native copper vein,
Washington Island, Minnesota

http://www.geo.mtu.edu/KeweenawGeoheritage/

The Mineralogical Barrier Concept

(after Skinner, 1979)



Photos: geology.com & crystalclassics.co.uk

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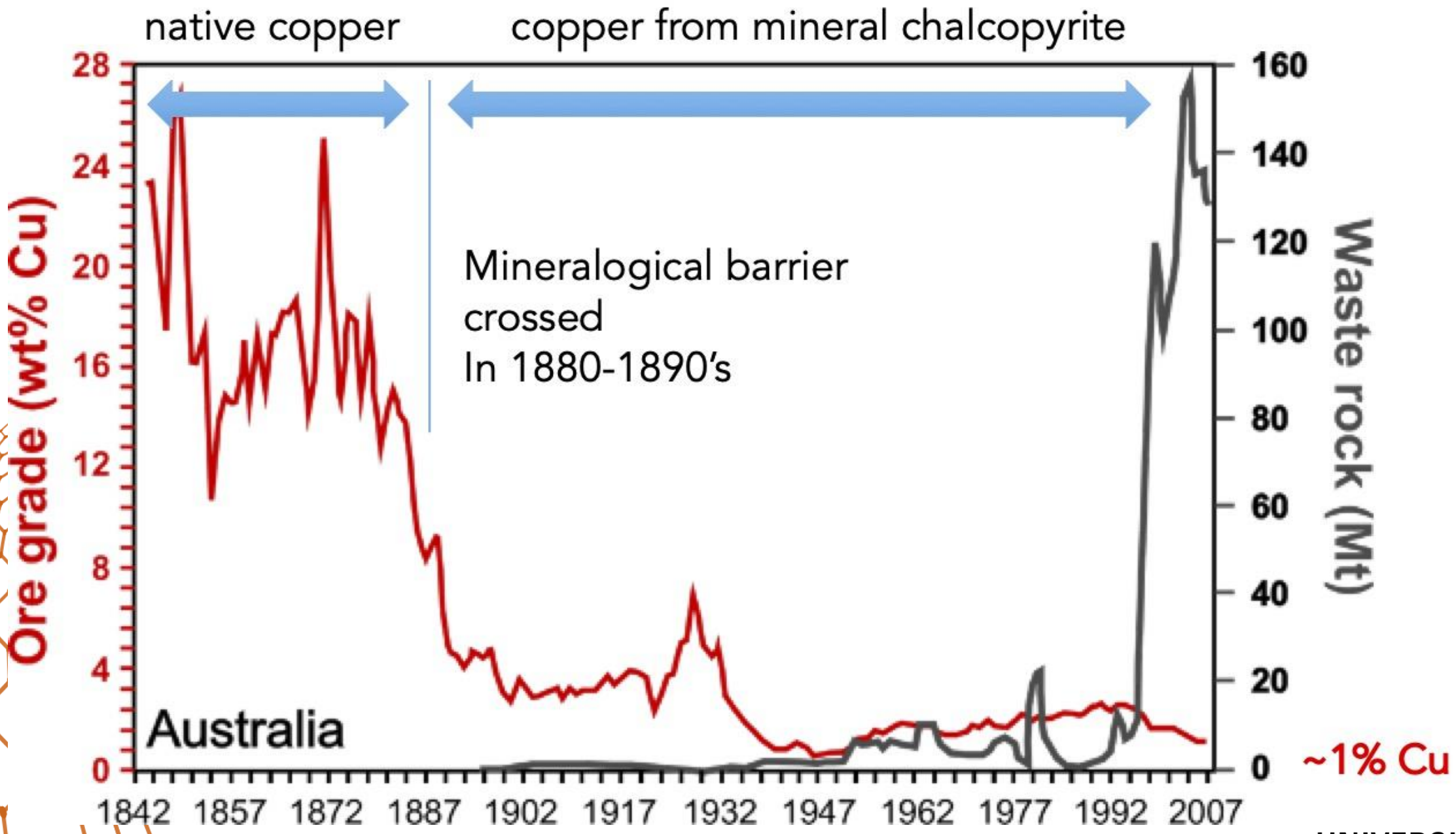

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Redrawn from Mudd, 2009. The Sustainability of Mining in Australia: Key Production Trends and Their Environmental Implications for the Future

World Mine Production and Reserves: Reserves for multiple countries were revised based on reported company data and (or) information from the Governments of those countries.

Values in Kton

	Mine production		Reserves[7]
	2018	2019[e]	
United States	1,220	1,300	51,000
Australia	920	960	[8]87,000
Chile	5,830	5,600	200,000
China	1,590	1,600	26,000
Congo (Kinshasa)	1,230	1,300	19,000
Indonesia	651	340	28,000
Kazakhstan	603	700	20,000
Mexico	751	770	53,000
Peru	2,440	2,400	87,000
Russia	751	750	61,000
Zambia	854	790	19,000
Other countries	3,540	3,800	220,000
World total (rounded)	20,400	20,000	870,000

World Resources: A 2014 U.S. Geological Survey assessment of copper deposits indicated that identified resources contained about 2.1 billion tons of copper, and undiscovered resources contained an estimated 3.5 billion tons.[9]

https://www.usgs.gov/centers/nmic/copper-statistics-and-information

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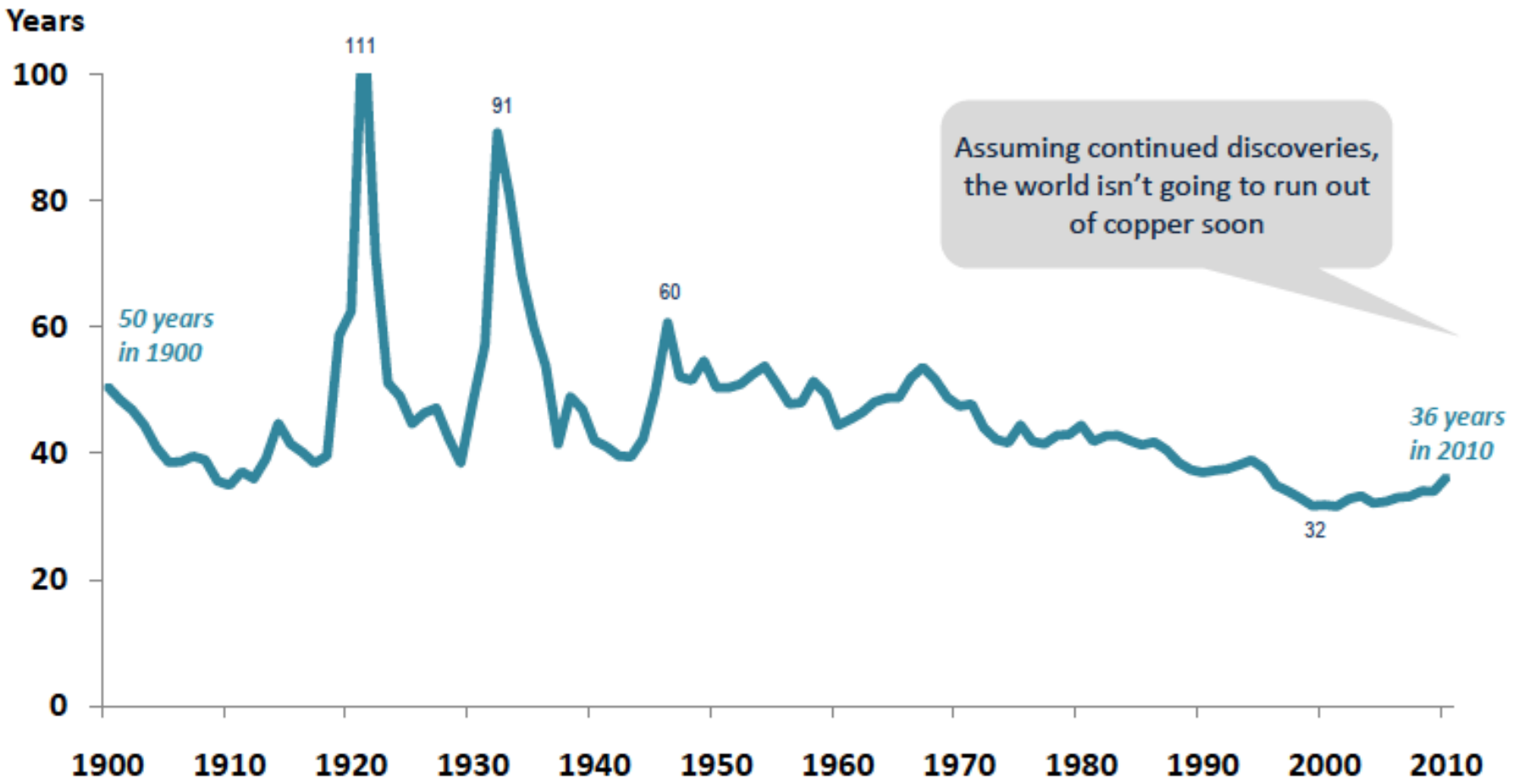
Reserve to production ratio (r/p)

870 Mt/ 20 Mt = 43.5

So only 43.5 years of copper left, at current rate of usage ???

Ratio of Reserves/Production - World: 1900-2010



Sources: Production data from USGS
Reserve data MinEx Consulting March 2010

Note: Chart based on "Estimated Reserves"
Peaks in 1921 and 1932 due to sudden drop in production

43.5 years in 2019 (and 2020)

From: Schodde (2010) The key drivers behind resource growth: An analysis of the copper industry over the last 100 years

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level of confidence

economic viability

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical (or)	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUBECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Occurrences	Includes nonconventional and low-grade materials				

After McKelvey (1973)

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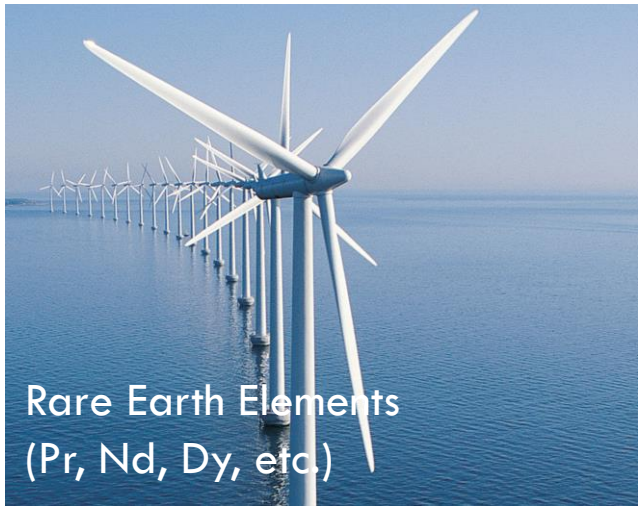

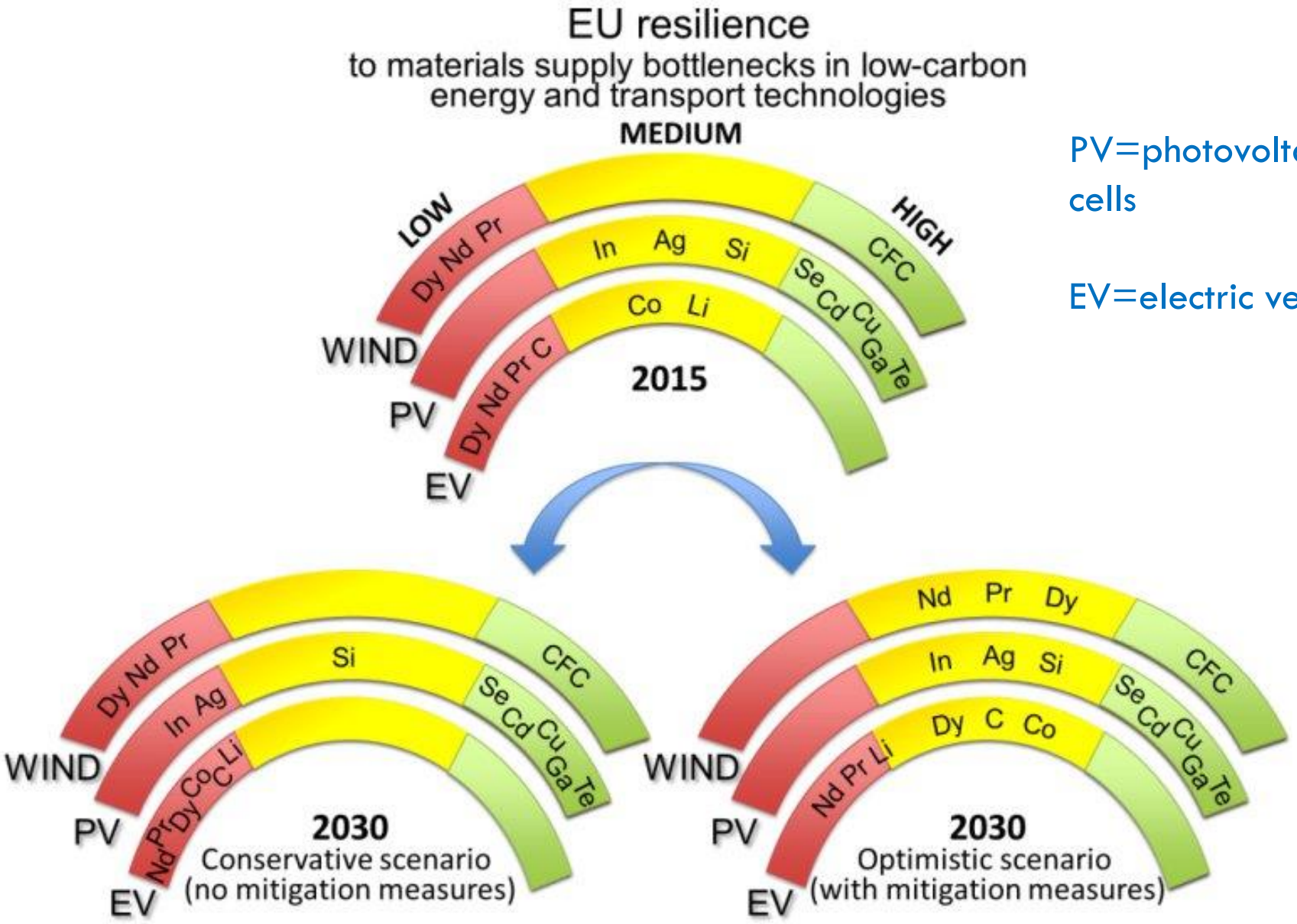

PV=photovoltaic cells

EV=electric vehicles

ec.europa.eu (Dec. 1st 2016)

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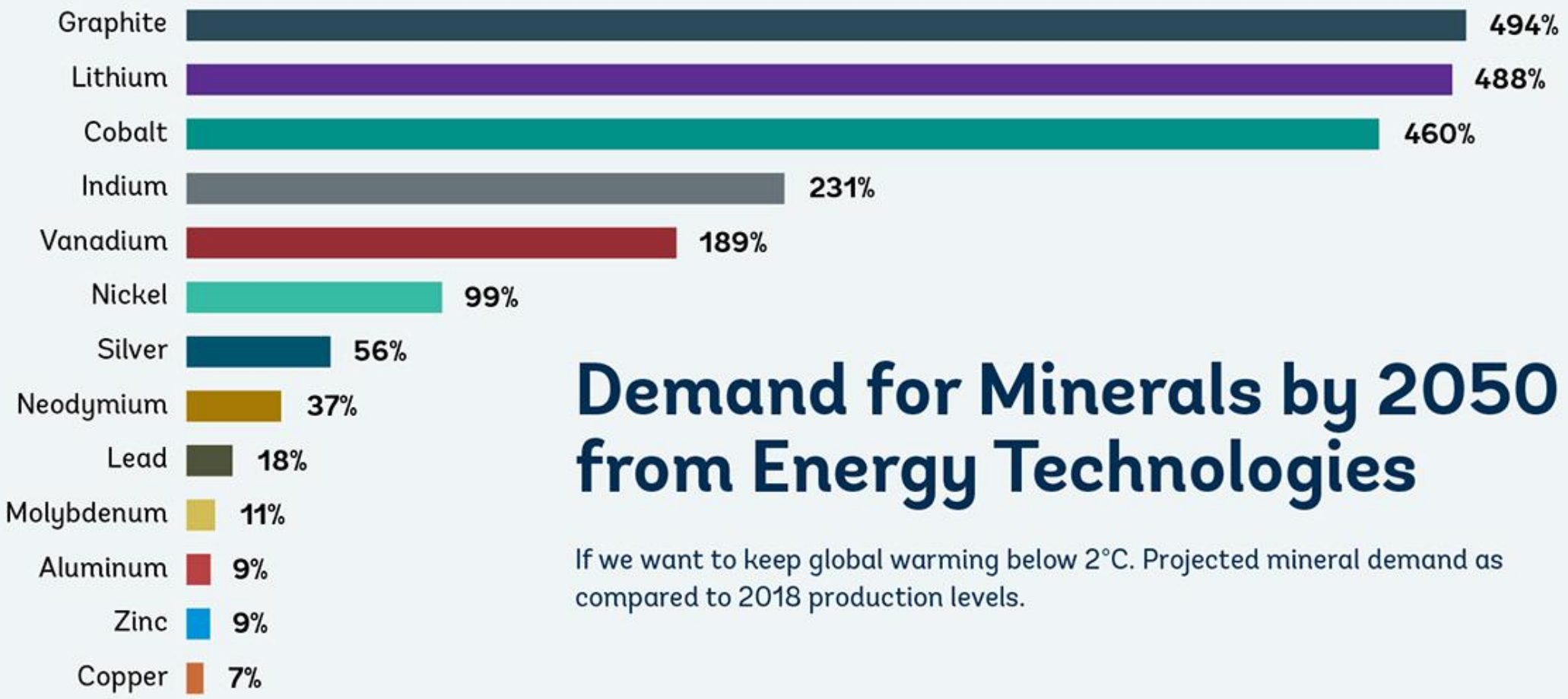

Demand for Minerals by 2050 from Energy Technologies

If we want to keep global warming below 2°C. Projected mineral demand as compared to 2018 production levels.

Minerals for Climate Action:
The Mineral Intensity
of the Clean Energy Transition

WORLD BANK GROUP

Climate **Smart** Mining

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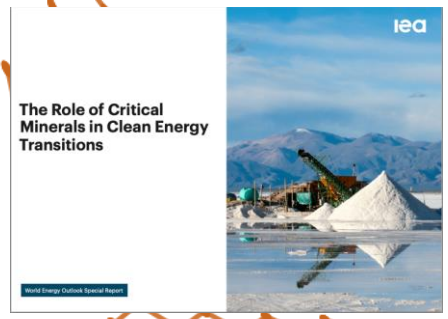
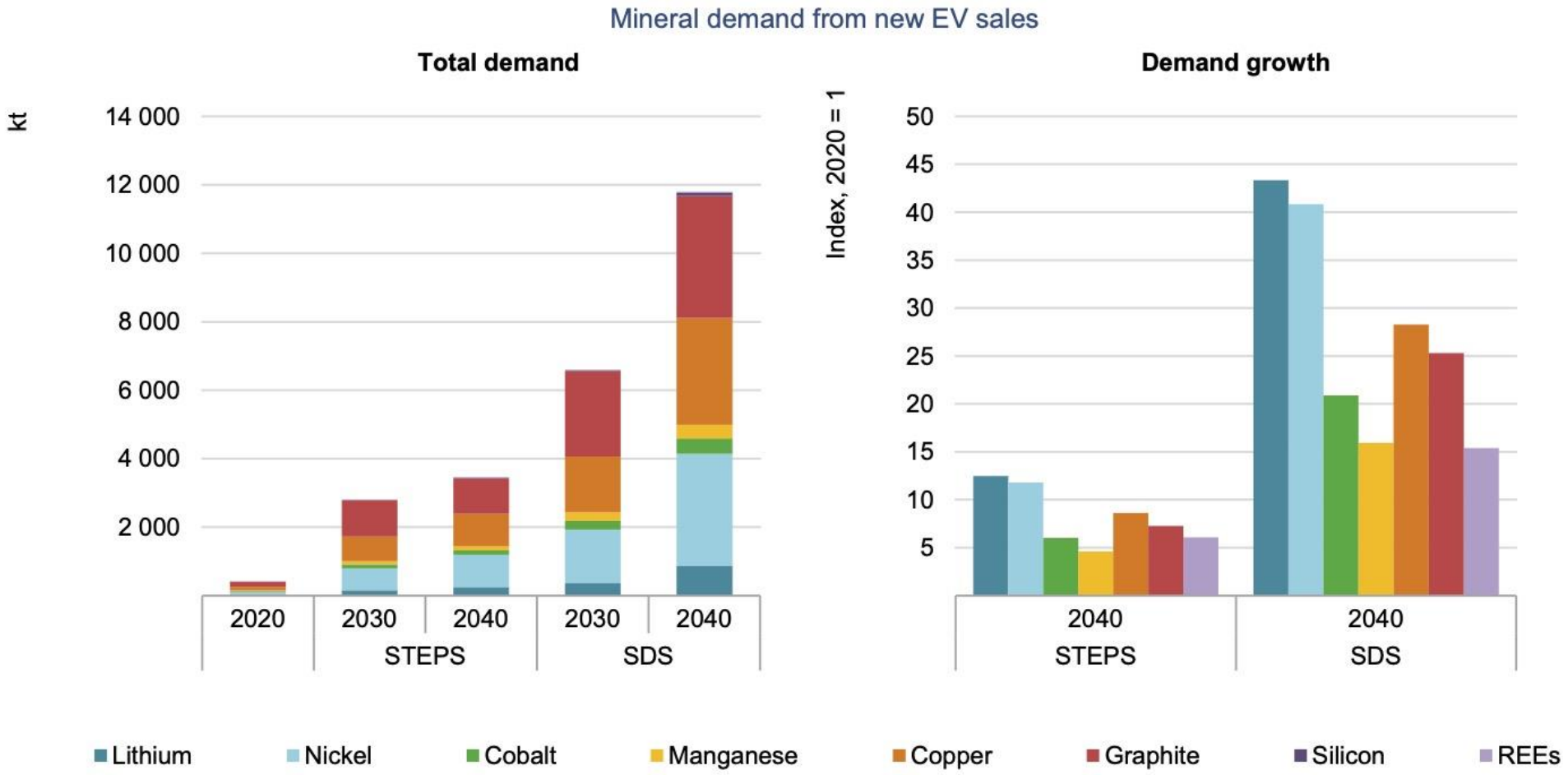


Mineral demand for EVs in the SDS grows by nearly 30 times between 2020 and 2040, with demand for lithium and nickel growing by around 40 times



STEPS: Stated Policies Scenario

SDS: Sustainable Development Scenario aligned with Paris Agreement

International Energy Agency (2021) The role of critical minerals in clean energy transitions

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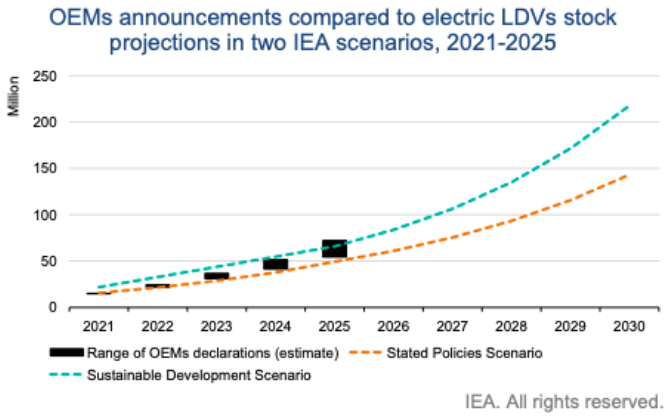
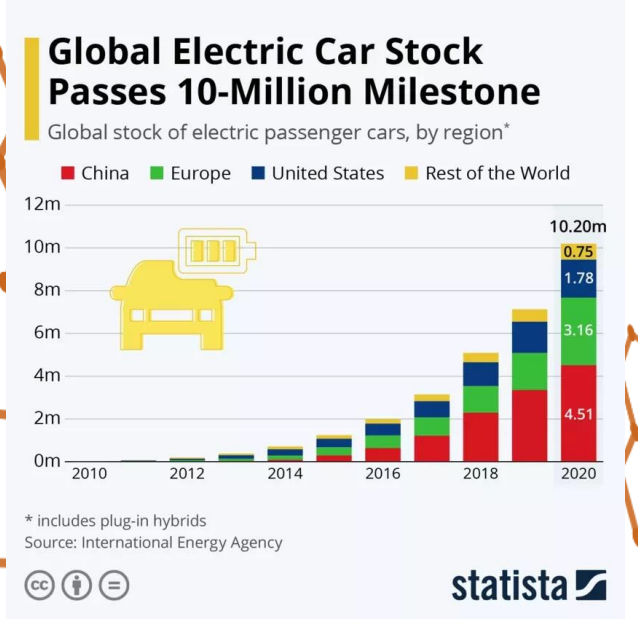
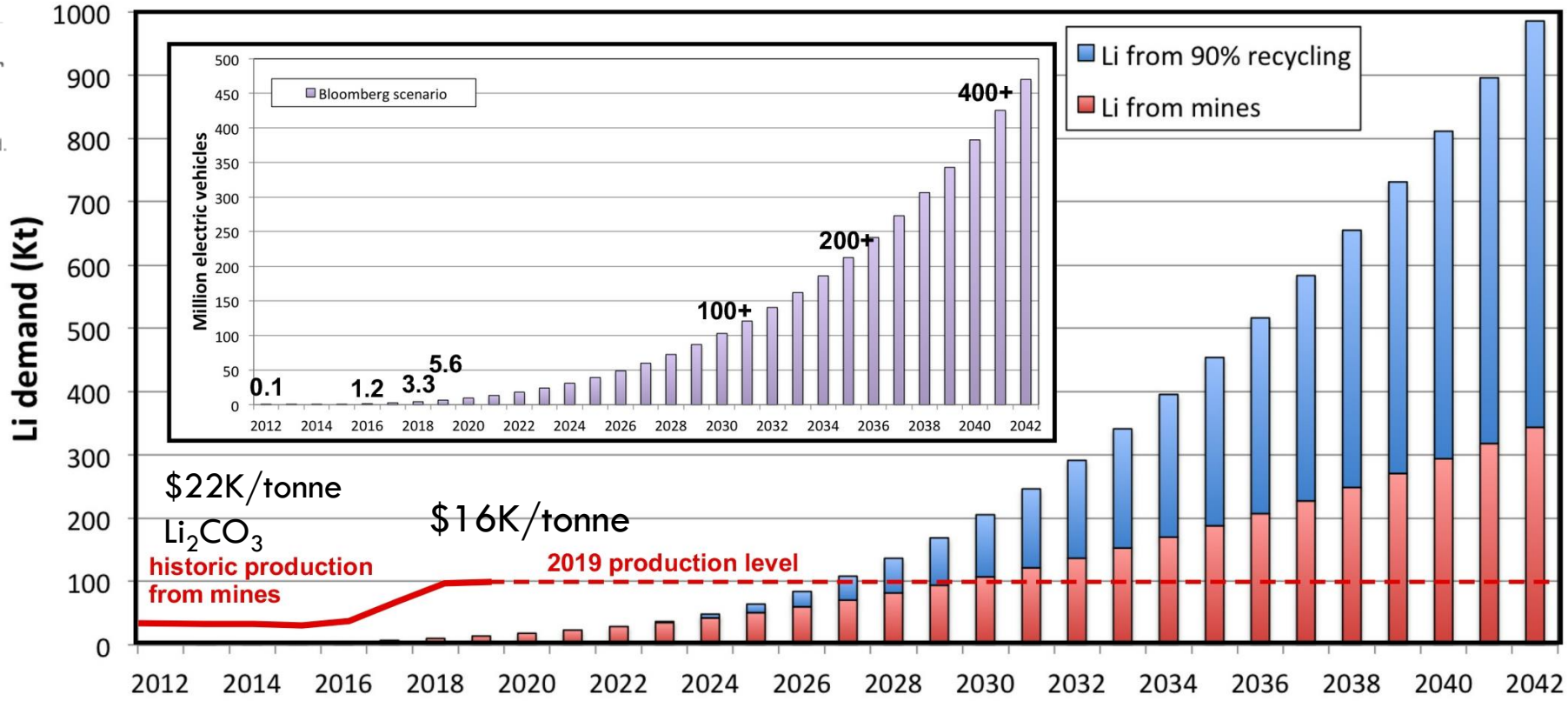




Demand for lithium due to electric vehicle explosion (90% recycling scenario)



- Bloomberg scenario for EV growth
- 6 kg Li/vehicle
- 10 year replacement
- 90% recycling

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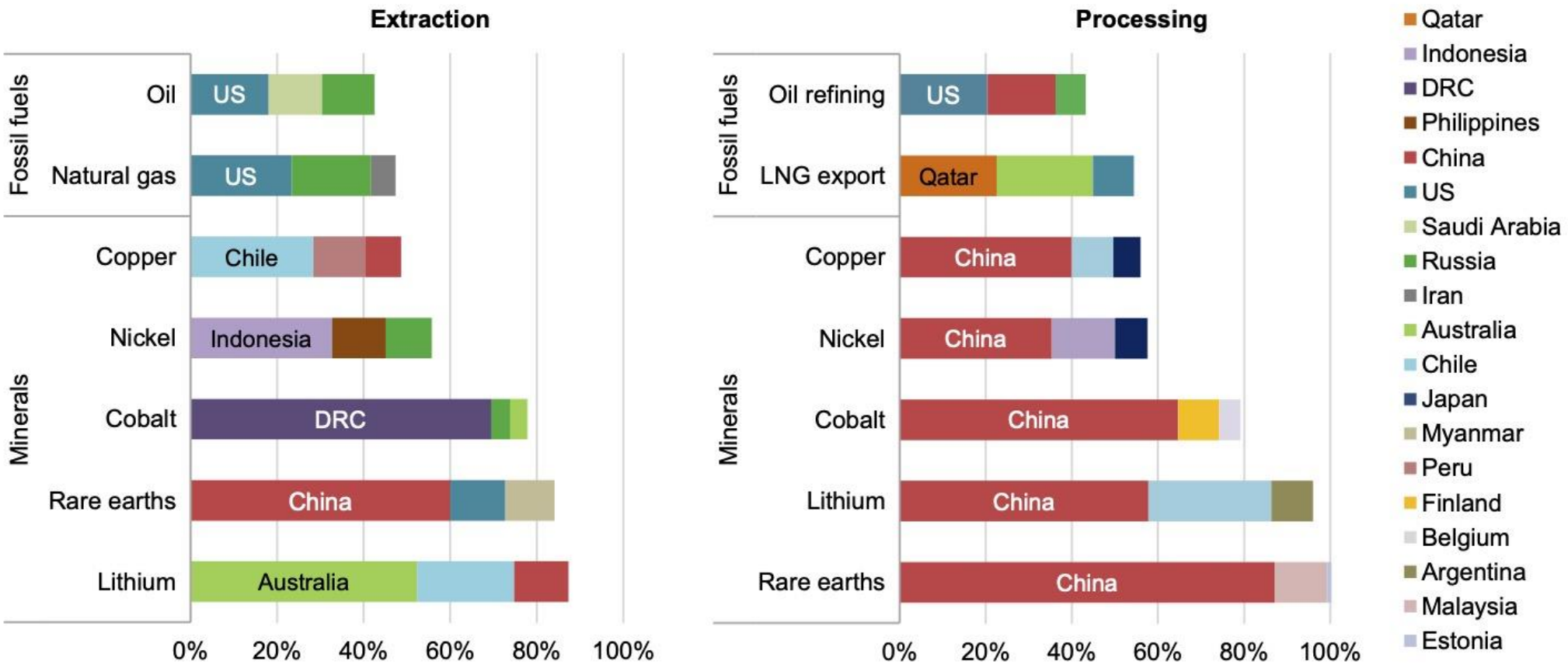
Production of many energy transition minerals today is more geographically concentrated than that of oil or natural gas

Share of top three producing countries in production of selected minerals and fossil fuels, 2019



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International Energy Agency (2021) The role of critical minerals in clean energy transitions

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Senkaku Islands diplomatic crisis (China v Japan/US), Sept. 2010

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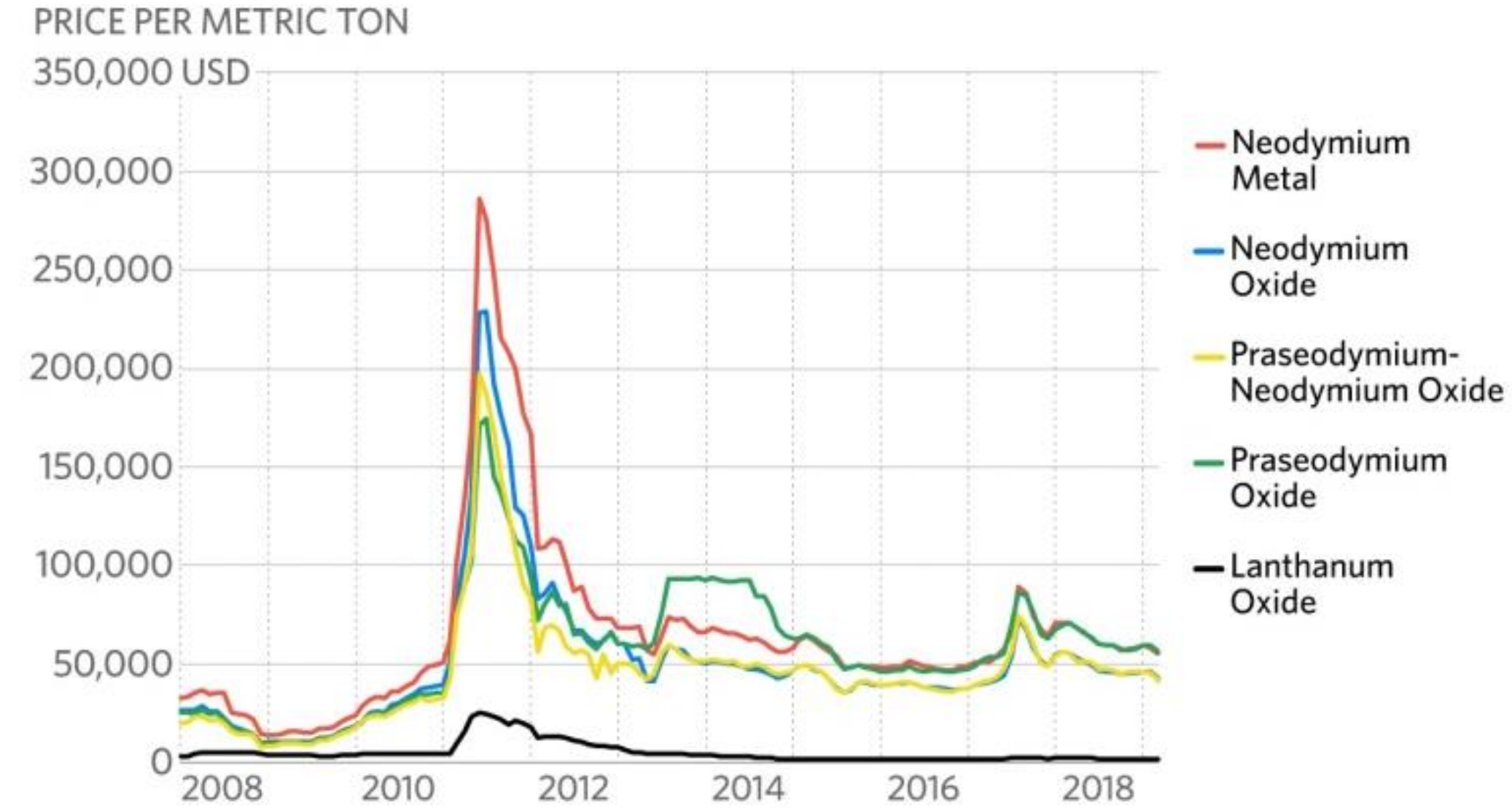

Source: Bloomberg

Copyright Stratfor 2019

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Biden to order review of U.S. reliance on overseas supply chains for semiconductors, rare earths - CNBC

By Reuters Staff

2 MIN READ

Salar de Uyuni

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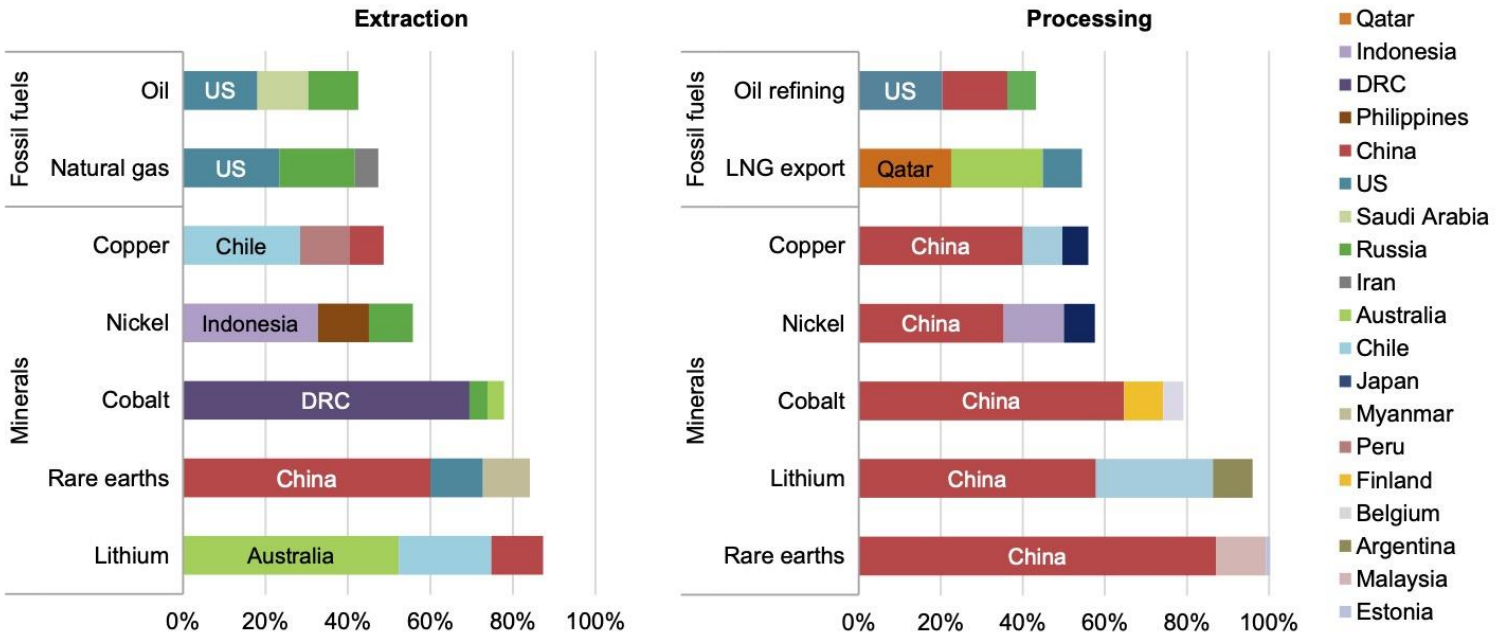
Production of many energy transition minerals today is more geographically concentrated than that of oil or natural gas

Share of top three producing countries in production of selected minerals and fossil fuels, 2019



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Cheaper Tesla? Panasonic to develop cobalt-free battery

Japanese electronics giant expects to start production in two to three years

Panasonic and Tesla are working to eliminate expensive cobalt from EV batteries, which account for 30% to 40% of the cost of the cars. (Source photos by Itsuro Fujino and EPA/Jiji)

Volkswagen engages in improving working conditions in artisanal cobalt mines in the Democratic Republic of Congo

- Volkswagen joins "Cobalt for Development", a cross-industry initiative launched by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Sustainable cobalt mining is important cornerstone of electrification
- Project activities improve living and working conditions for miners and their communities
- Ullrich Gereke, Head of Procurement Strategy at Volkswagen AG: "We want to deliver impact on the ground."

Artisanal mining cooperatives in Kolwezi.

As a responsible company, Volkswagen is actively engaging in improving artisanal cobalt mining conditions in the Democratic Republic of Congo as well as the living conditions for people in the surrounding communities. Cobalt is an important raw material for the production of electric vehicle batteries. Artisanal mining involves risks to the environment and people. Volkswagen has joined the "Cobalt for Development" initiative and is thus supporting efforts to minimize these risks.

The pilot project intends to strengthen legal compliance and improve health and safety conditions as well as social well-being in the south of the Democratic Republic of Congo, where 70 percent of the world's cobalt resources are located. The first trainings for mine operators and miners have just begun. The project is being implemented by GIZ and financed by BASF, BMW Group, Google, Samsung Electronics, Samsung SDI and ...

OECD — BETTER POLICIES FOR BETTER LIVES — 60 YEARS

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OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas

Helping industries meet responsible sourcing expectations

The OECD Due Diligence Guidance provides detailed recommendations to help companies respect human rights and avoid contributing to conflict through their mineral purchasing decisions and practices. This Guidance is for use by any company potentially sourcing minerals or metals from conflict-affected and high-risk areas. The OECD Guidance is global in scope and applies to all mineral supply chains.

The 3rd Edition of the OECD Due Diligence Guidance was published in April 2016. This booklet contains the OECD Council Recommendation, the text of the Guidance, the 3Ts Supplement and the Gold Supplement. The updated version clarifies that the Guidance provides a framework for detailed due diligence as a basis for responsible supply chain management of minerals, including tin, tantalum, tungsten and gold, as well as all other mineral resources. In addition to the 37 OECD Members, 9 non-Members, namely Argentina, Brazil, Costa Rica, Croatia, Kazakhstan, Morocco, Peru and Romania and Ukraine, adhered to the Council Recommendation.

Apple & other tech giants seek dismissal of cobalt mine child labor suit

Mike Wuerthele | Aug 27, 2020

Were Your Solar Panels Made With Conflict Minerals?

A new report rates solar manufacturers on the environmental and social impact of their products.

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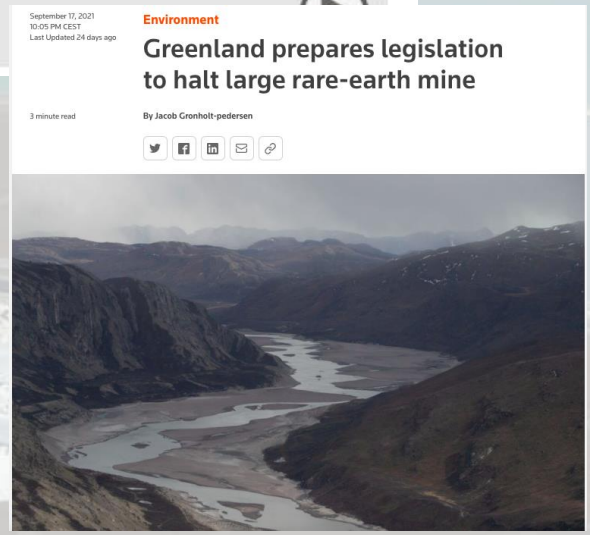
The social dimension

Salar mining in South America at risk of rapidly losing 'social license to operate' due to water shortage concerns

www.ntr.nl/Bodem-in-zicht/384

Gas exploitation Groningen



Salar de Uyuni, Bolivia: Lithium reserves 5.5 MT, Resource estimate 21 MT

Argentina: Li resource size estimate 19 MT

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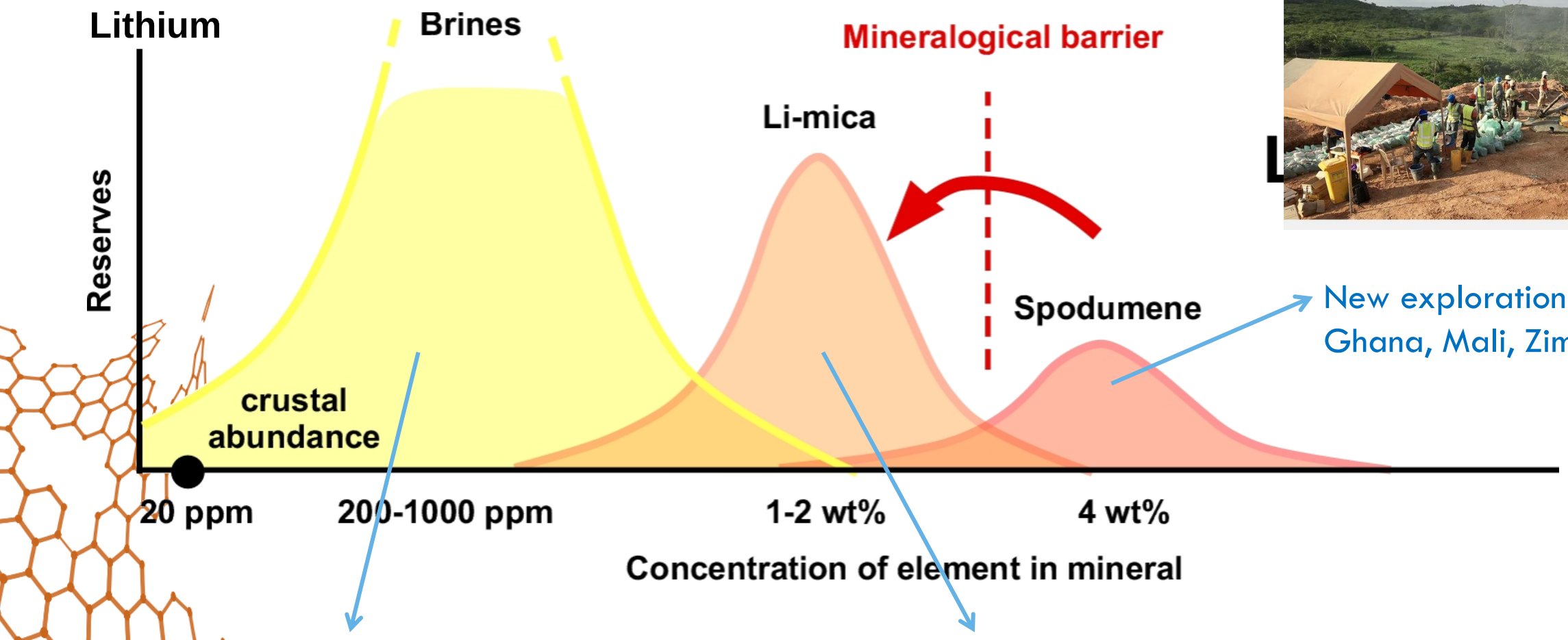
Solution: diversify supply of critical raw materials (geography, type of resource)



New exploration projects in Ghana, Mali, Zimbabwe

Salar de Atacama (Chile): 1400 ppm
Salar de Uyuni (Bolivia): 500 ppm
Cornwall mine waters: 100-200 ppm
Seawater: 0.2 ppm

New exploration projects in St. Austell (UK), Cinovec (Czech Republic), Mt Cattlin (W. Australia),

Alvarroes (Portugal) to start production

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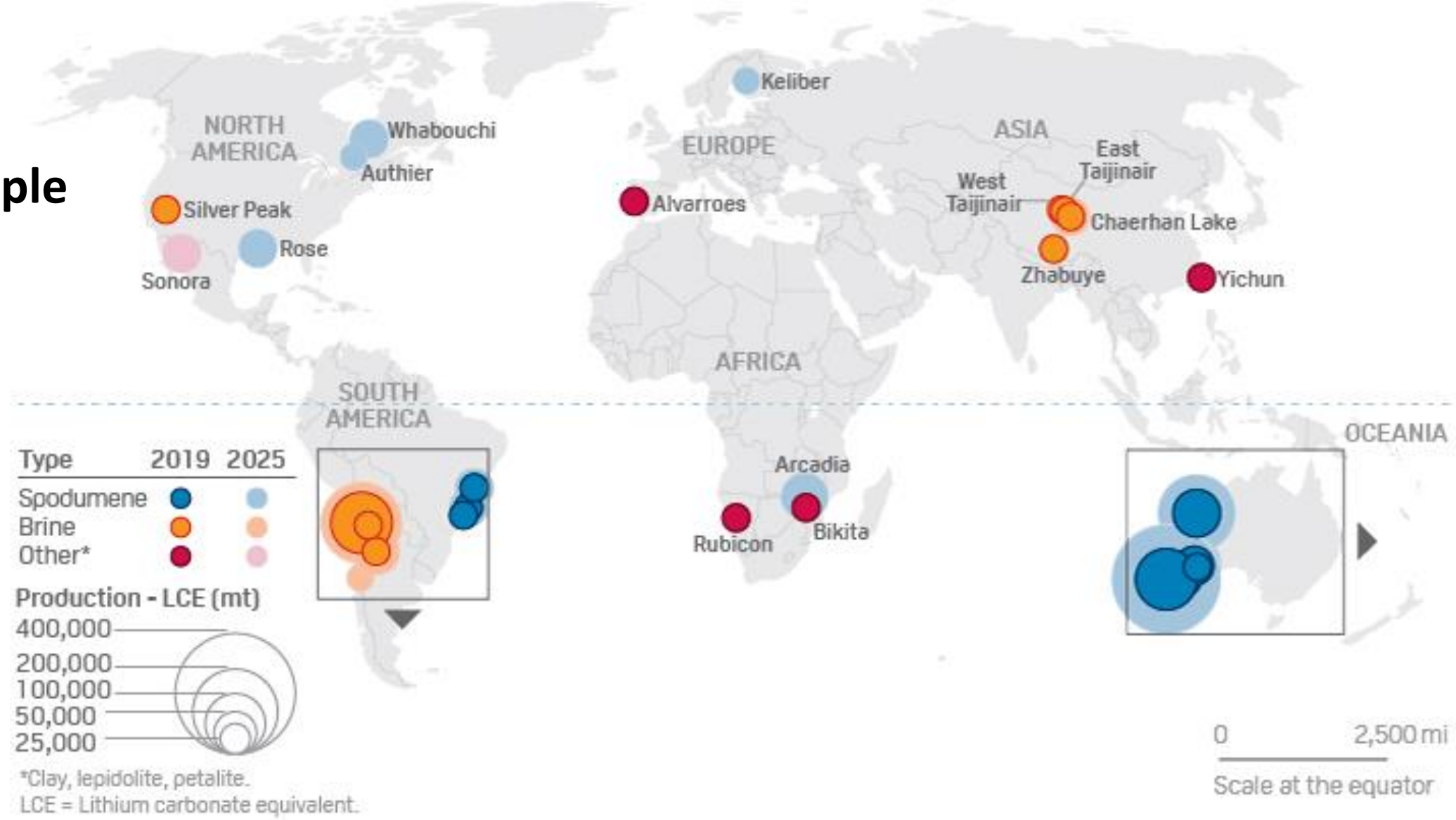
Solution: diversify supply of critical raw materials (geography, type of resource)

Supply to triple by 2025



https://www.spglobal.com/en/research-insights/articles/lithium-supply-is-set-to-triple-by-2025-will-it-be-enough

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Solution: circular economy, increase recycling

Circular Economy

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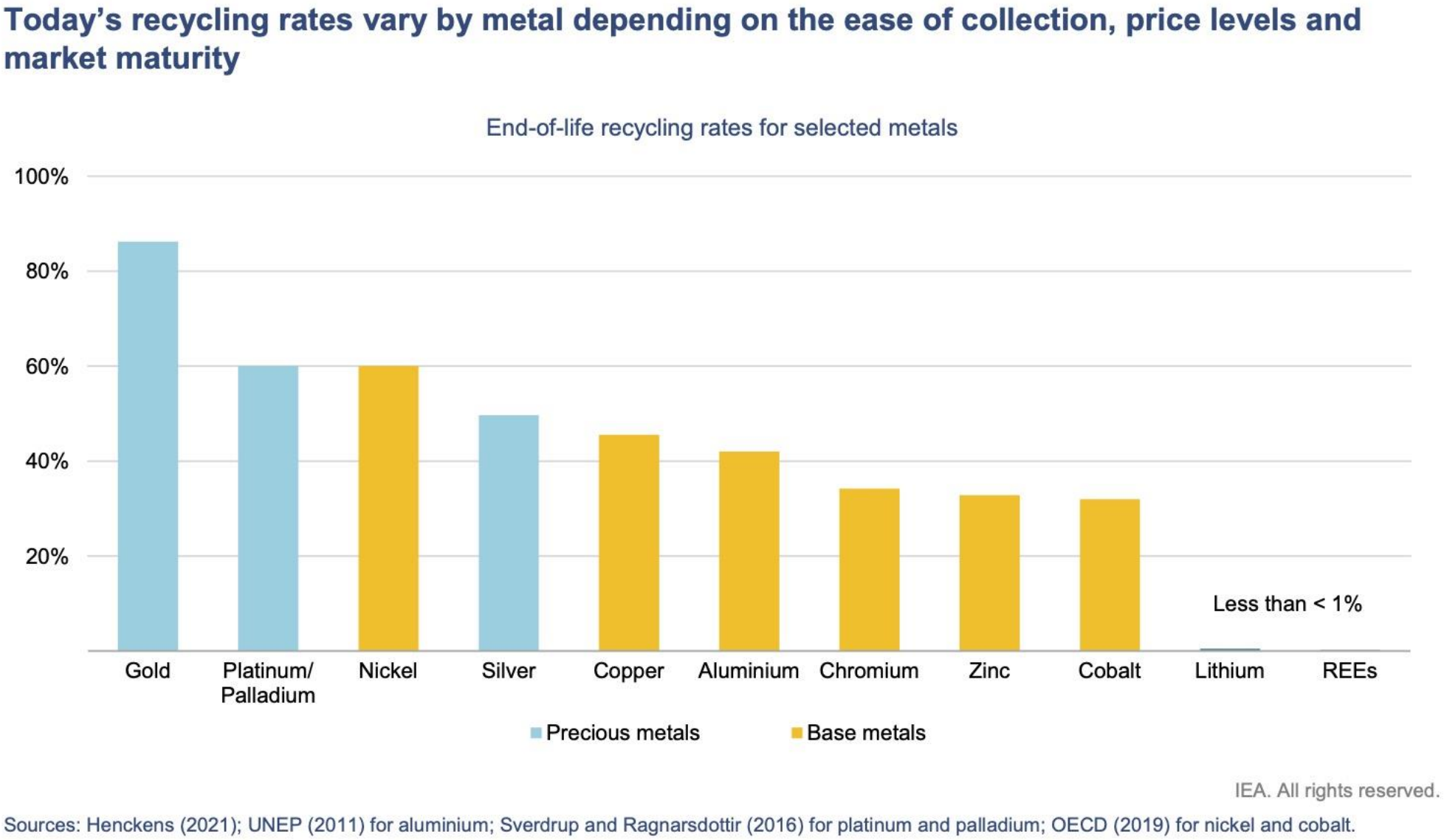
Solution: circular economy, increase recycling



International Energy Agency (2021) The role of critical minerals in clean energy transitions

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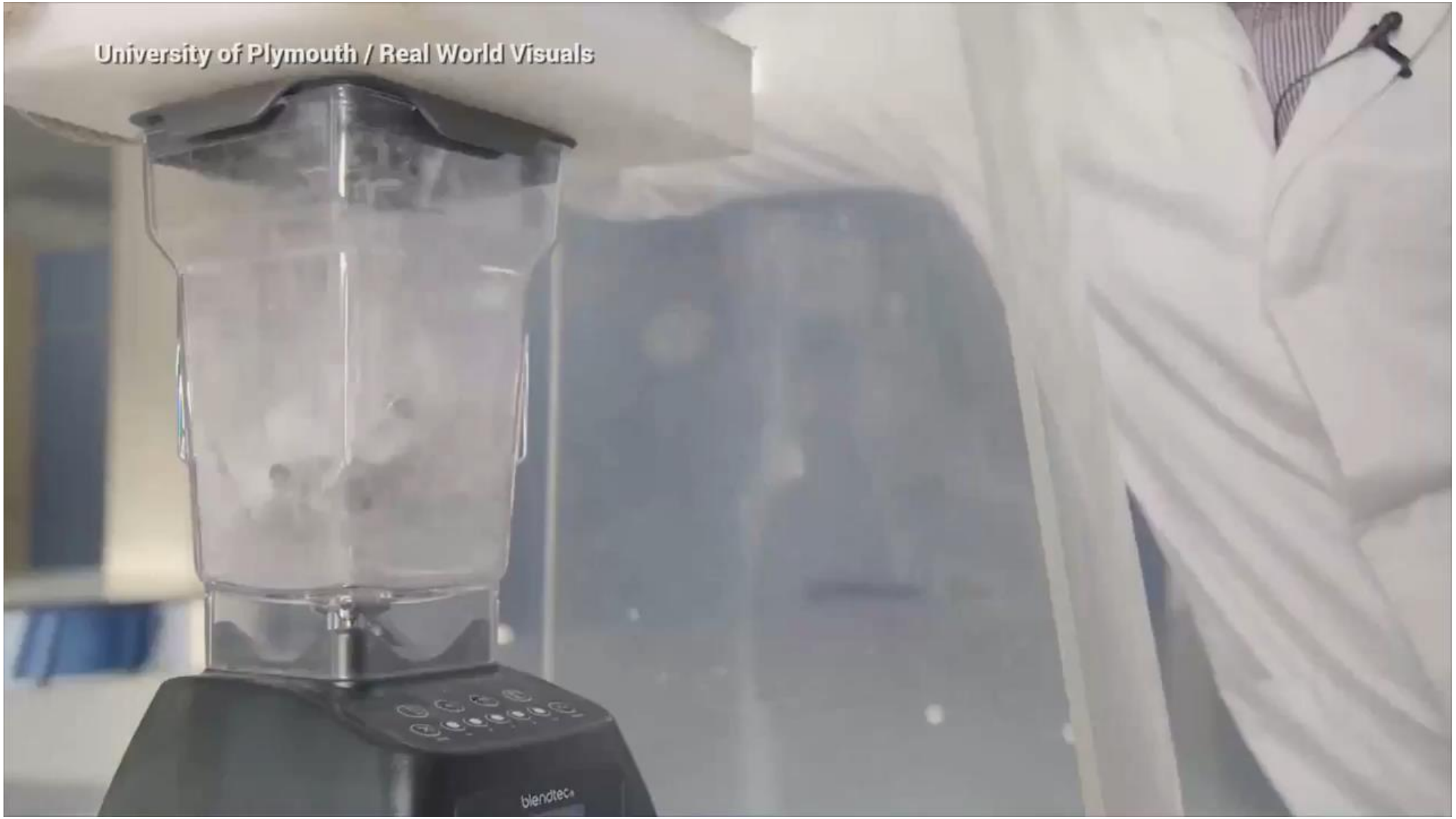

https://www.youtube.com/watch?v=bhuWmcDT05Q for original full video

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Conclusies ‘Zijn de grondstoffen voor de energie transitie (en mobiliteits transitie) schaars ?”

- **Er is meer dan genoeg**! Maar doordat we steeds laaggradiger ertsen (en pekels voor Li) zullen gaan gebruiken om aan de enorme groei van de vraag te voldoen, wordt de ecologische & sociaal-economische **‘footprint’** van de mijnbouw steeds groter.
- Vooral materialen zoals lithium, cobalt en zeldzame aardmetalen kunnen de **energie transitie vertragen** in het geval van schaarste op de markt (critical raw materials).
- De **quasi-monopolies** van sommige landen wat betreft **mijnbouw** en **opwerking/raffinage** vormt een gevaar voor de betrouwbaarheid van de aanvoer.
- Voor sommige materialen (lithium, grafiet) is het maar de vraag of de mijnbouw het **groeitempo** van de vraag kan bijbenen; voor lithium is het echt ‘alle hens aan dek’!

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