NORWEGIAN PETROLEUM DIRECTORATE
50 years

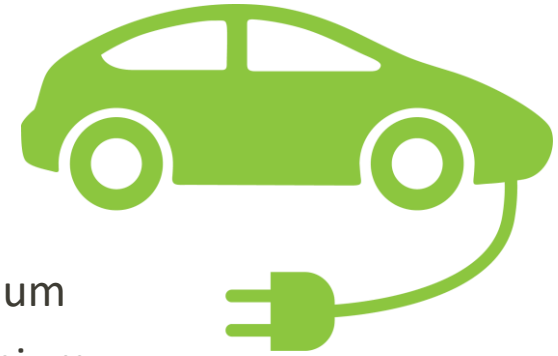
Seabed Minerals

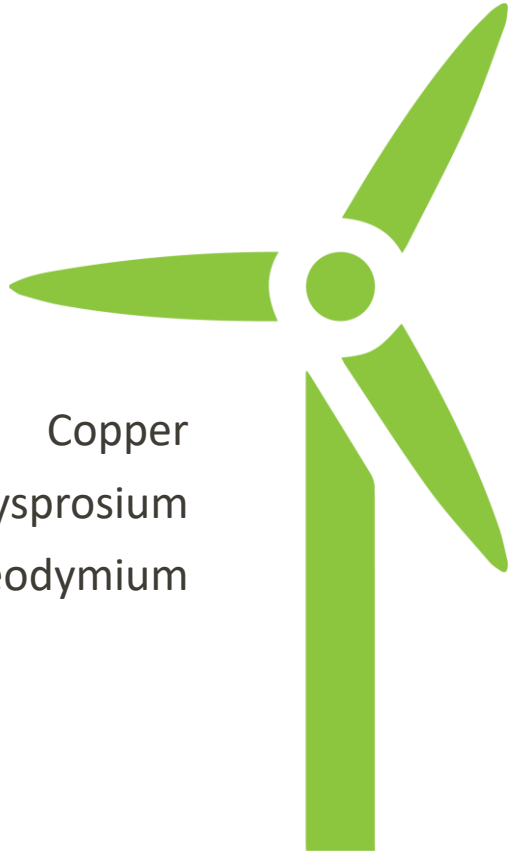
Harald Brekke

Electricity Demands Metals

Examples of necessary elements in a modern world

Copper
Lithium
Cobalt
Lanthanides:
Dysprosium
Europium
Ytterbium
Cerium
Praseodymium
Neodymium
Terbium





Copper
Dysprosium
Neodymium

Some Critical Metals - IEA

Critical mineral needs for clean energy technologies

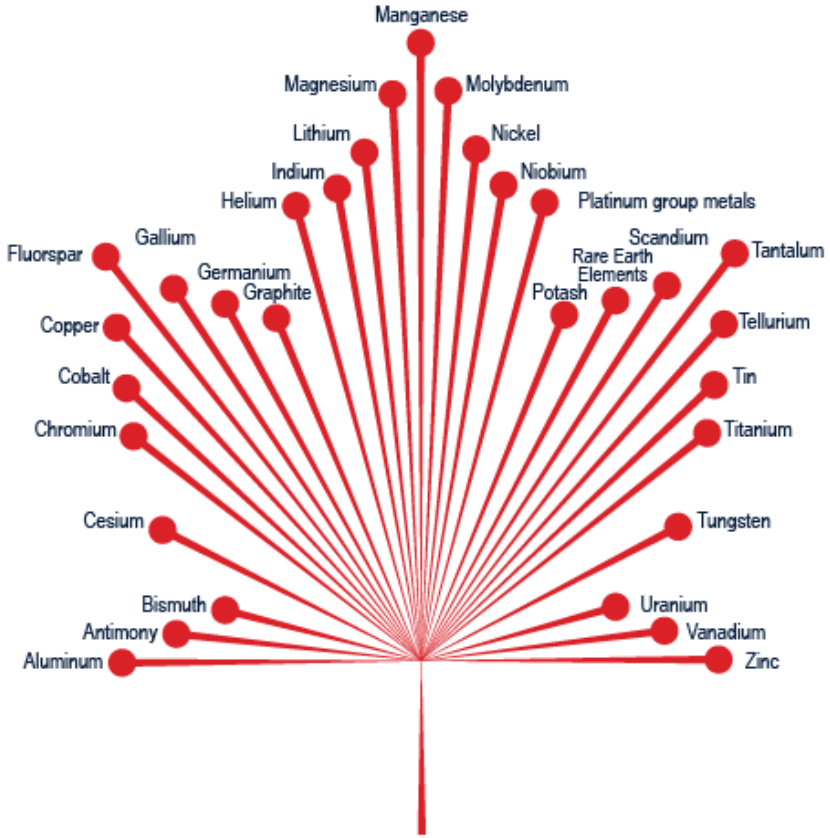
	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminium
Solar PV	●	●	●	●	●	●	●	●	●
Wind	●	●	●	●	●	●	●	●	●
Hydro	●	●	●	●	●	●	●	●	●
CSP	●	●	●	●	●	●	●	●	●
Bioenergy	●	●	●	●	●	●	●	●	●
Geothermal	●	●	●	●	●	●	●	●	●
Nuclear	●	●	●	●	●	●	●	●	●
Electricity networks	●	●	●	●	●	●	●	●	●
EVs and battery storage	●	●	●	●	●	●	●	●	●
Hydrogen	●	●	●	●	●	●	●	●	●

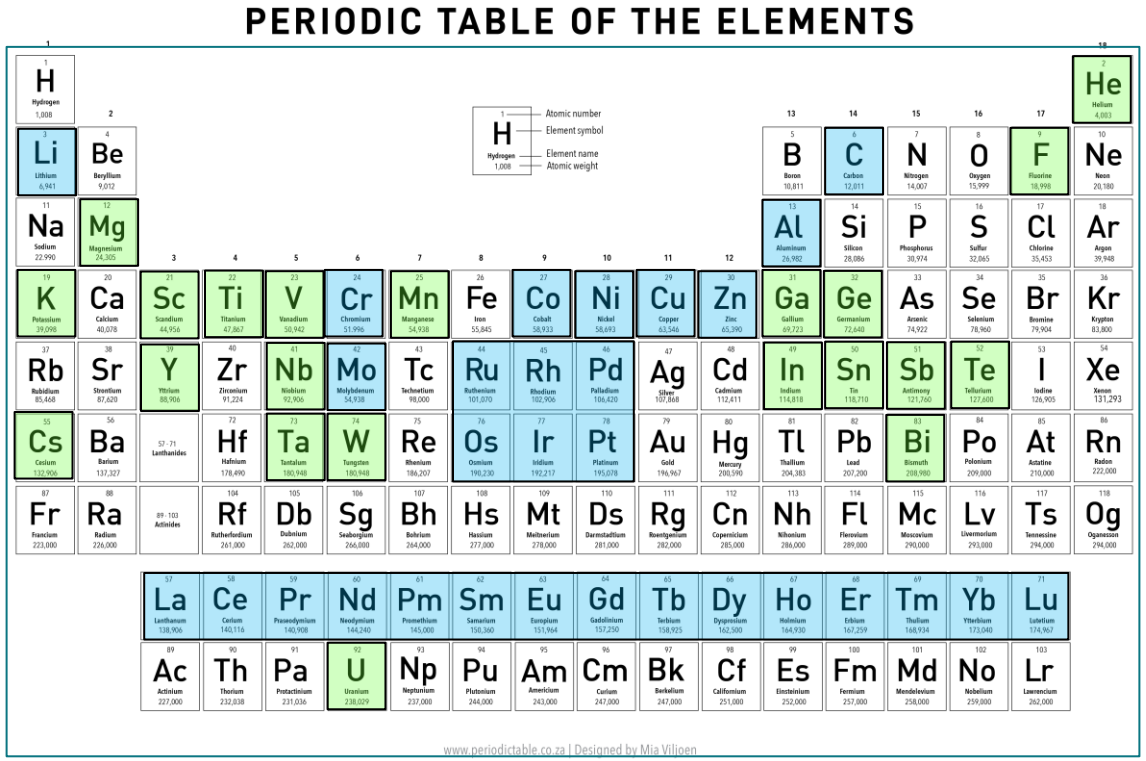
Relative importance of minerals for a particular clean energy technology: High: ● Moderate: ● Low: ●

Shading indicates the relative importance of minerals for a particular clean energy technology, which are discussed in their respective sections in this chapter. CSP = concentrating solar power; REEs = rare earth elements; PGM = platinum group metals. * In this report, aluminium demand is assessed for electricity networks only and is not included in the aggregate demand projections.

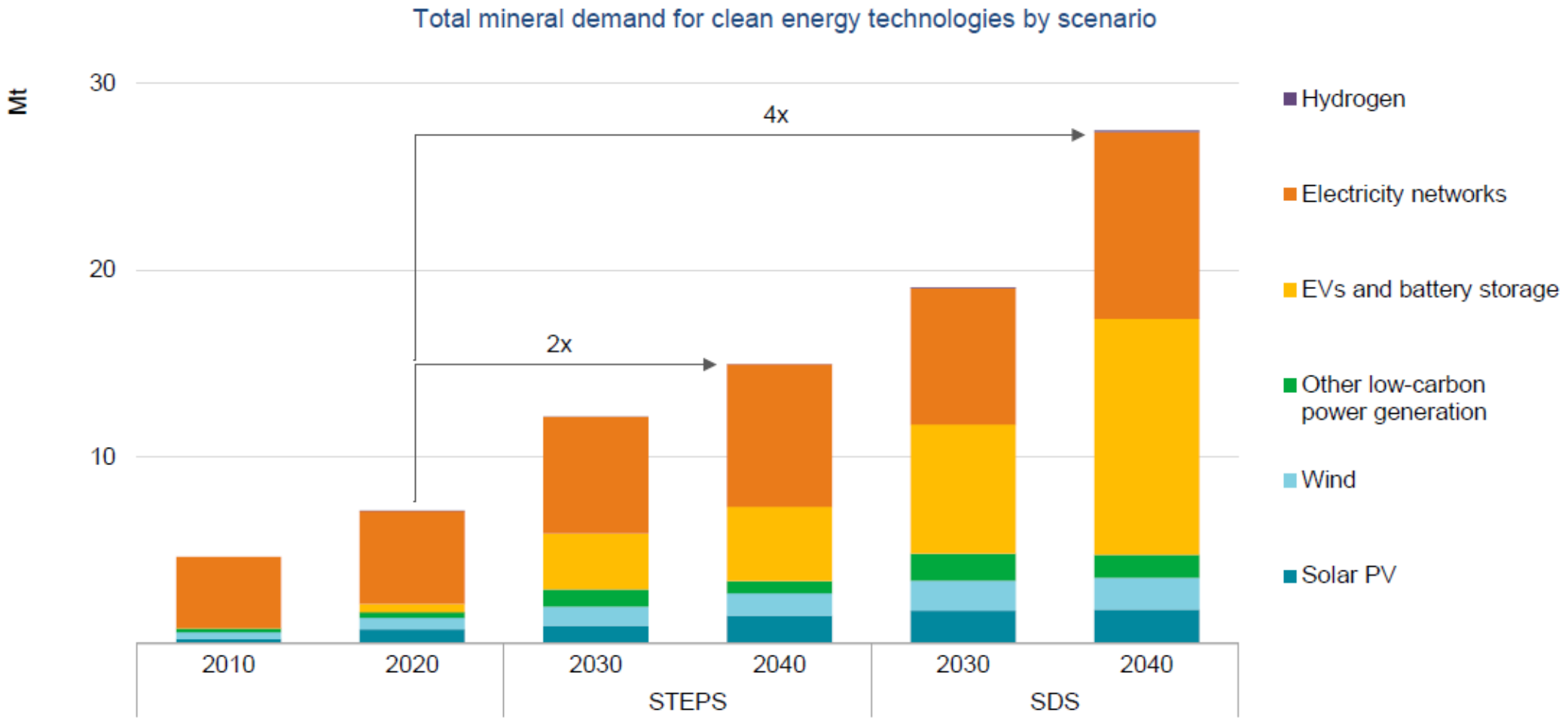
IEA The Role of Critical Minerals in Clean Energy Transitions (windows.net)

Critical Metals - Canada





Total mineral demand from clean energy technologies is set to double in the STEPS and quadruple in the SDS by 2040



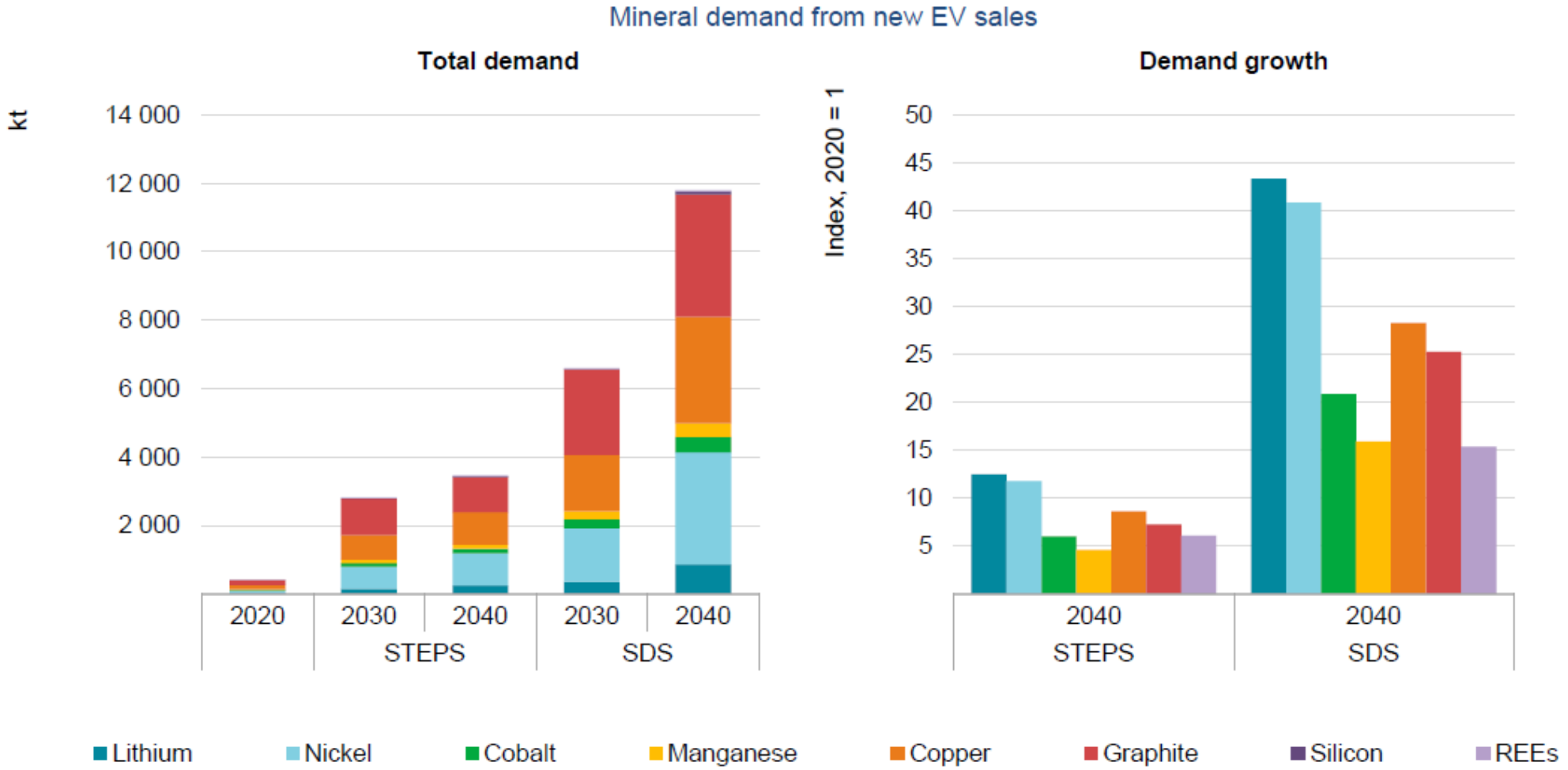
STEPS = Stated Policies Scenario, SDS = Sustainable Development Scenario

IEA. All rights reserved.

Notes: Includes all minerals in the scope of this report, including chromium, copper, major battery metals (lithium, nickel, cobalt, manganese and graphite), molybdenum, platinum group metals, zinc, REEs and others, but does not include steel and aluminium (see Annex for a full list of minerals). Mt = million tonnes.

The Role of Critical Minerals in Clean Energy Transitions (windows.net)

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



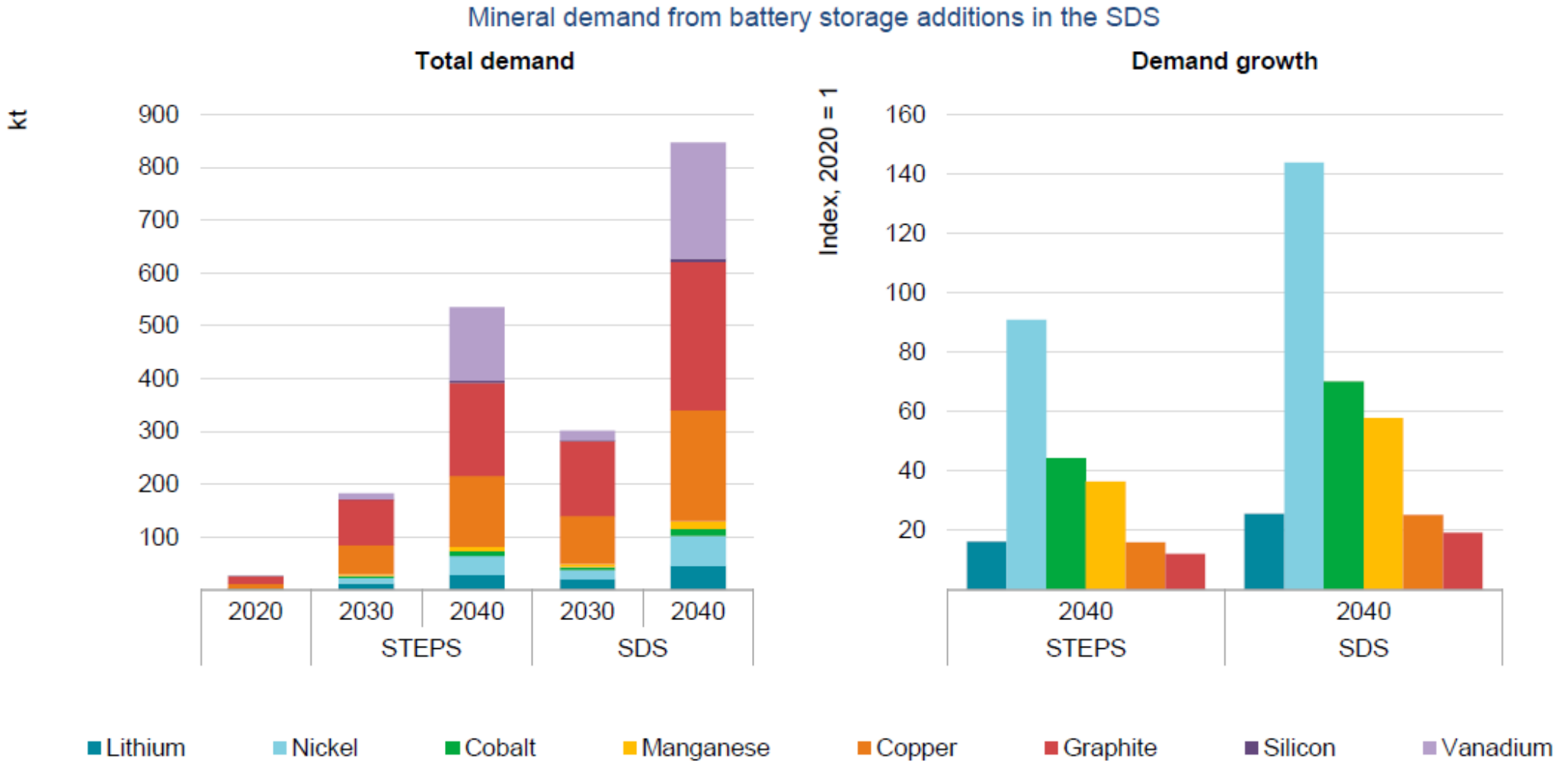
STEPS = Stated Policies Scenario, SDS = Sustainable Development Scenario

IEA. All rights reserved.

Note: Silicon is excluded from the demand growth graph due to its very high growth (over 500-fold increase), starting from a low base.

The Role of Critical Minerals in Clean Energy Transitions (windows.net)

Mineral demand for storage in the SDS grows by over 30 times between 2020 and 2040, with demand for nickel and cobalt growing by 140 times and 70 times respectively



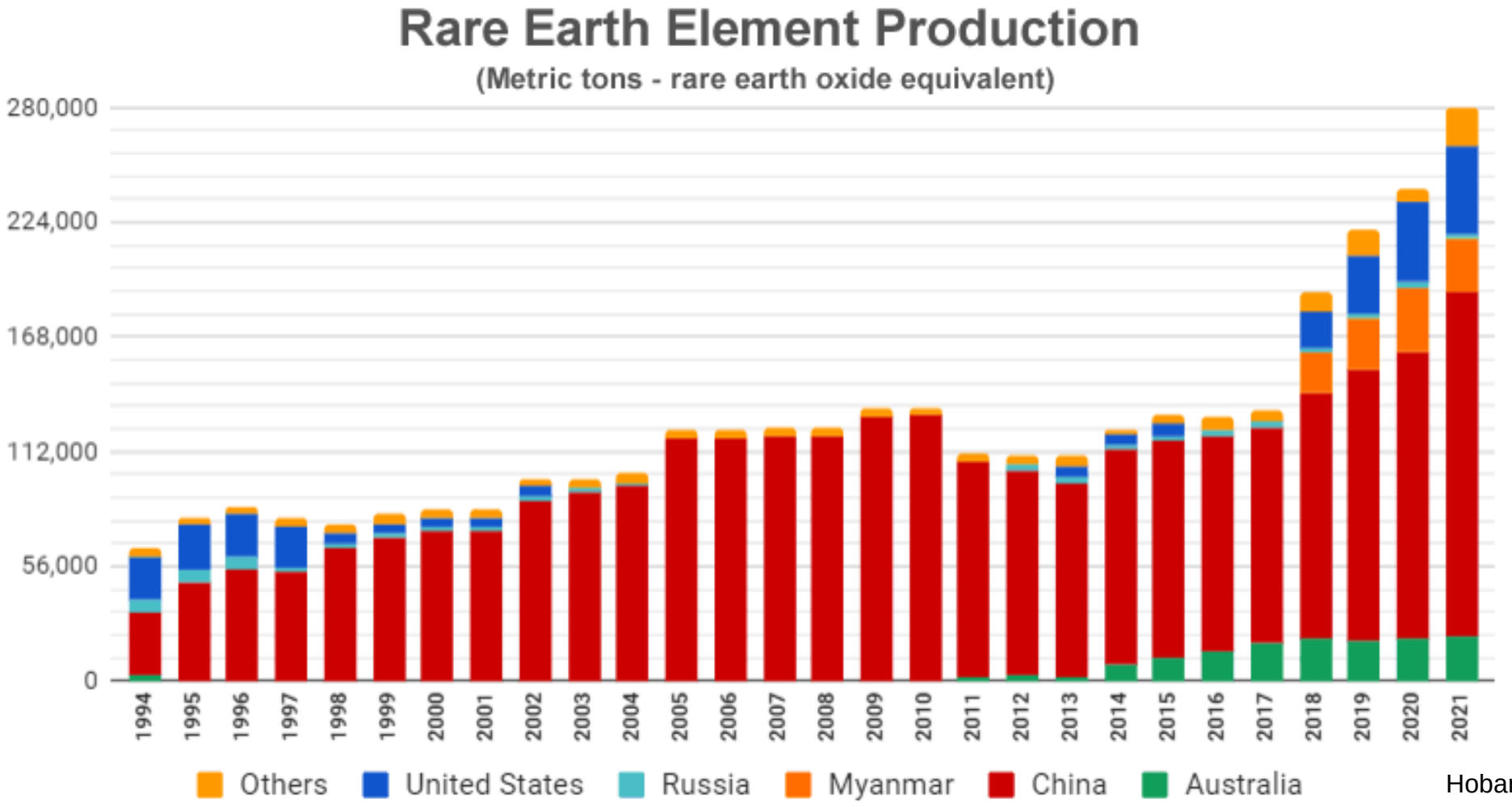
STEPS = Stated Policies Scenario, SDS = Sustainable Development Scenario

Note: Silicon and vanadium are excluded from the demand growth graph.

IEA. All rights reserved.

The Role of Critical Minerals in Clean Energy Transitions (windows.net)

REE Production

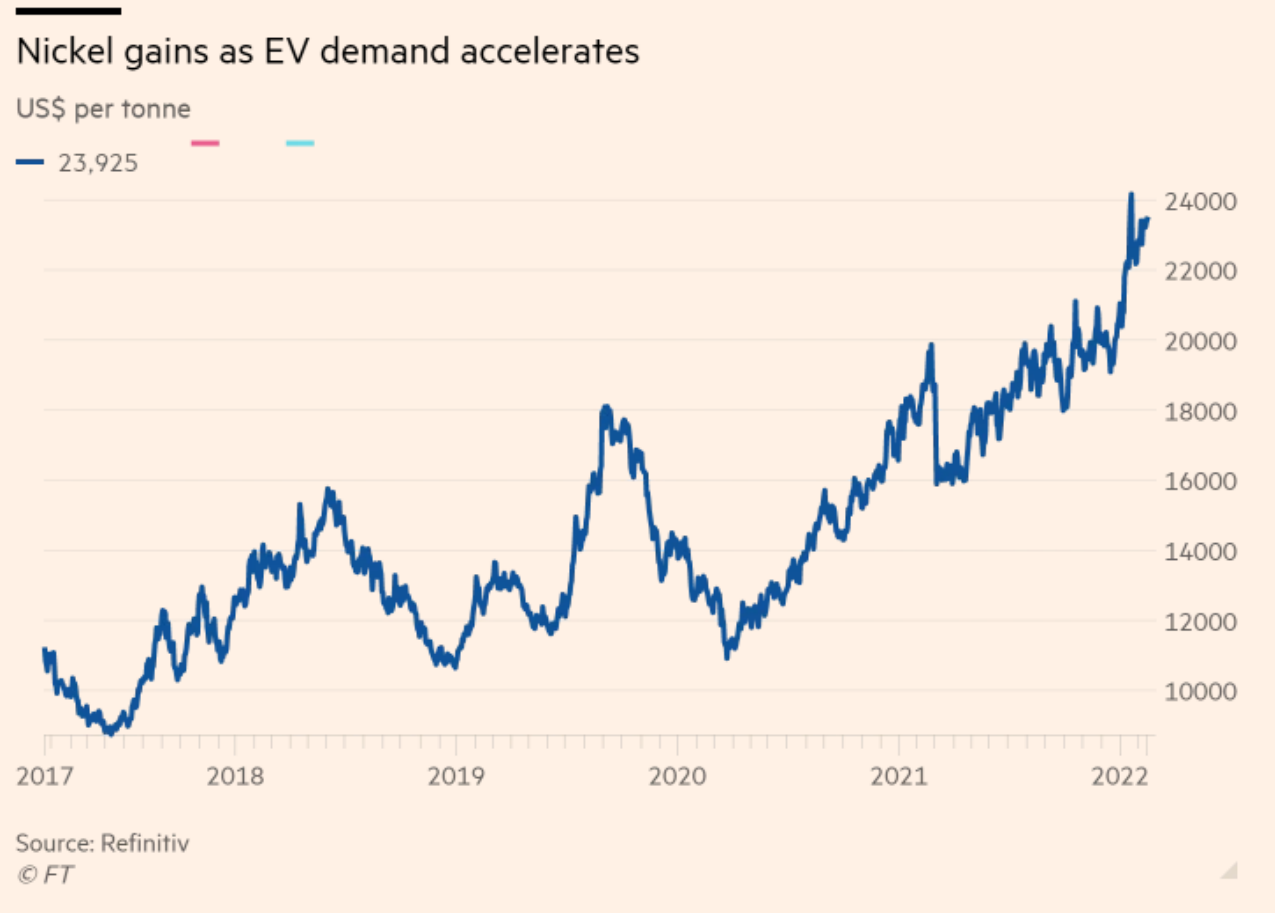


Hobart M. King, Geology.com

Copper Prices

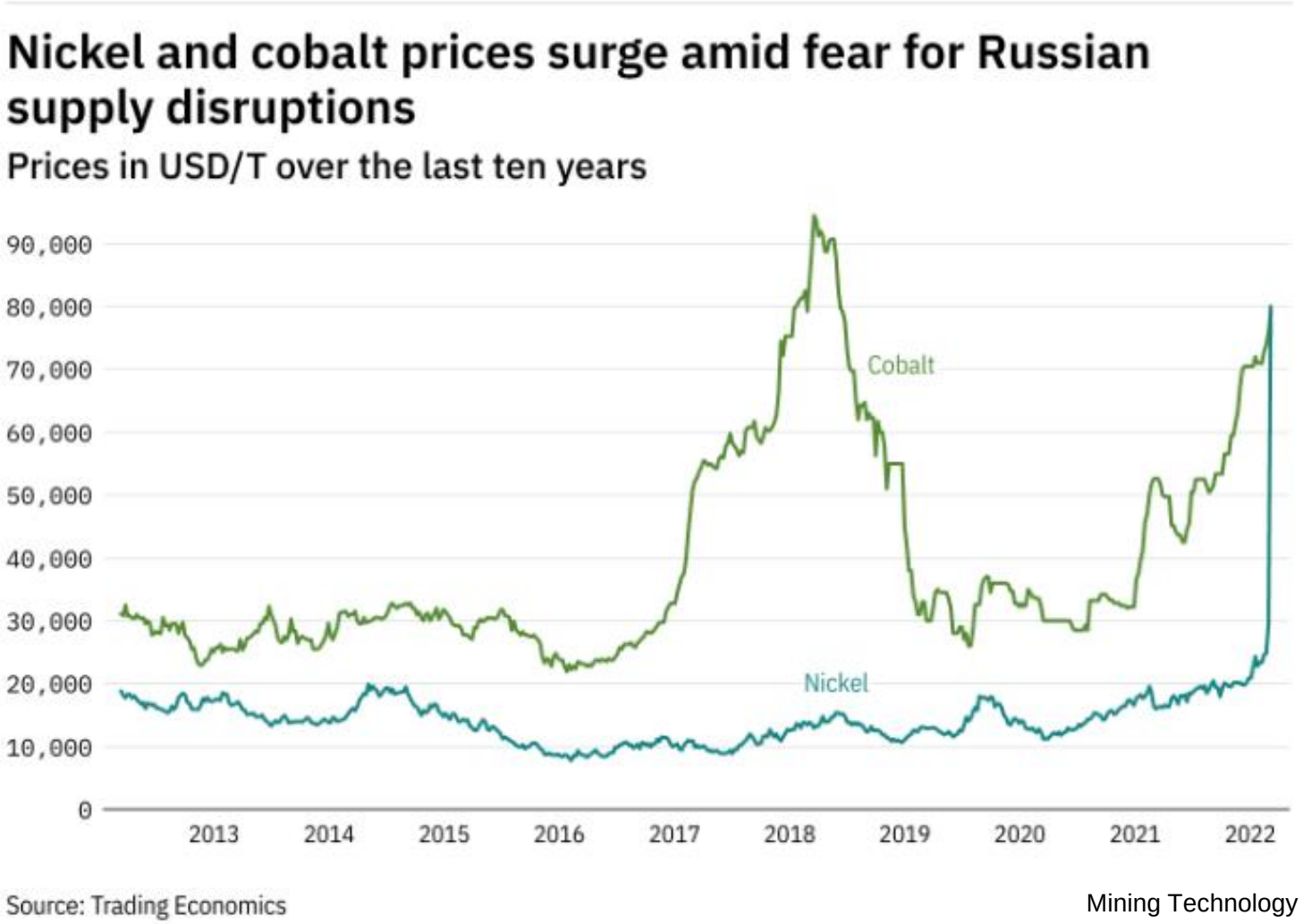
Is there a new supercycle in metals and minerals? | Financial Times (ft.com)

Nickel Prices

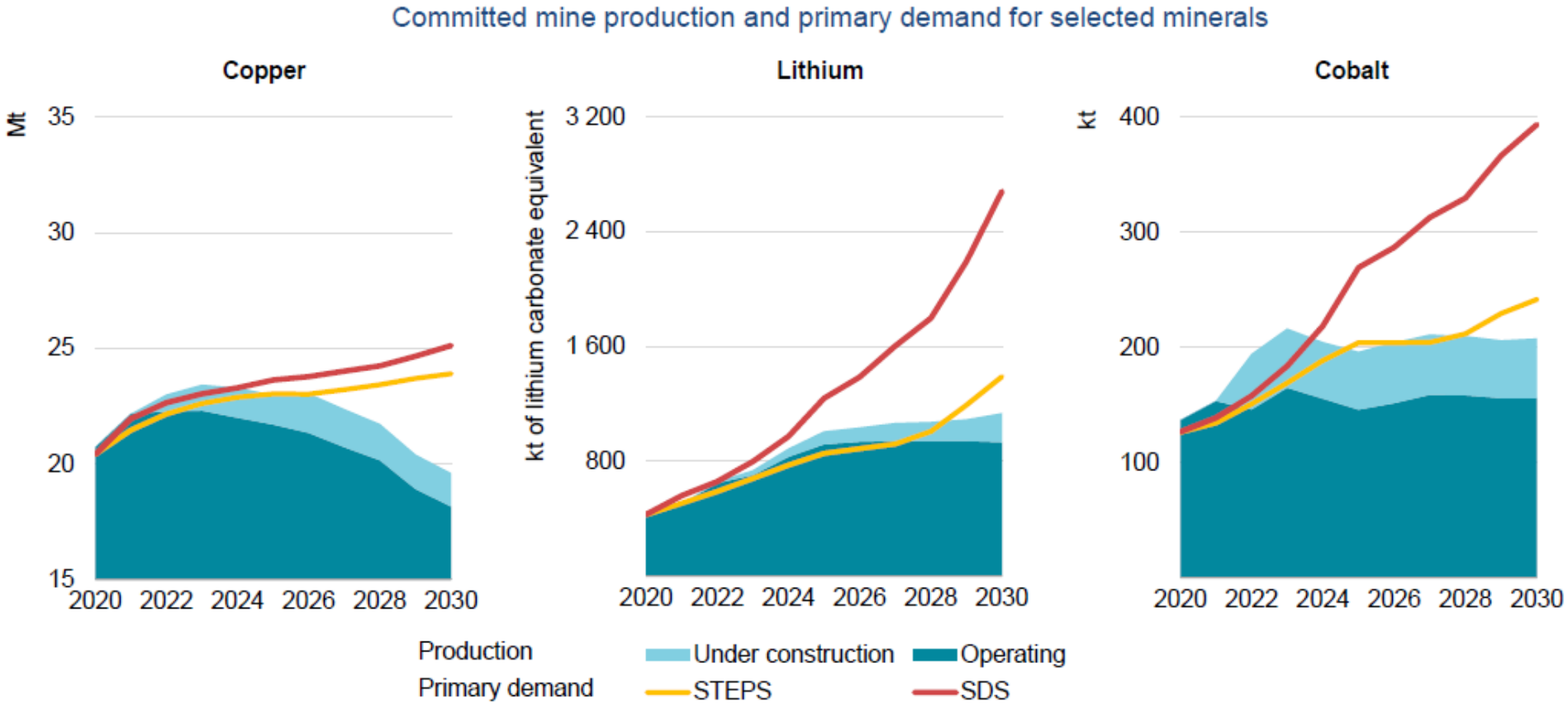


Is there a new supercycle in metals and minerals? | Financial Times (ft.com)

Nickel and Cobalt Prices



Meeting primary demand in the SDS requires strong growth in investment to bring forward new supply sources over the next decade



STEPS = Stated Policies Scenario, SDS = Sustainable Development Scenario

IEA. All rights reserved.

Notes: Primary demand is total demand net of recycled volume (also called primary supply requirements). Projected production profiles are sourced from the S&P Global Market Intelligence database with adjustments to unspecified volumes. Operating projects include the expansion of existing mines. Under-construction projects include those for which the development stage is indicated as commissioning, construction planned, construction started or preproduction. Mt = million tonnes.

Source: IEA analysis based on S&P Global (2021).

The Role of Critical Minerals in Clean Energy Transitions (windows.net)

Seabed minerals

Seabed Minerals – Types and Metal Content

1. Polymetallic Nodules – Ni, Cu, Mn, Co (Mo, REE, Li, Ti)
2. Polymetallic Crusts – Co, Ni, Mn, Cu (Ti, REE, Pt, Mo, Bi, V)
3. Polymetallic Sulphides – Cu, Zn, Au, Ag (Co,Pb, Ga, Ge, In, Sb)

Some Critical Metals

Critical mineral needs for clean energy technologies

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminium
Solar PV	●	●	●	●	●	●	●	●	●
Wind	●	●	●	●	●	●	●	●	●
Hydro	●	●	●	●	●	●	●	●	●
CSP	●	●	●	●	●	●	●	●	●
Bioenergy	●	●	●	●	●	●	●	●	●
Geothermal	●	●	●	●	●	●	●	●	●
Nuclear	●	●	●	●	●	●	●	●	●
Electricity networks	●	●	●	●	●	●	●	●	●
EVs and battery storage	●	●	●	●	●	●	●	●	●
Hydrogen	●	●	●	●	●	●	●	●	●

Relative importance of minerals for a particular clean energy technology: High: ● Moderate: ● Low: ●

Shading indicates the relative importance of minerals for a particular clean energy technology, which are discussed in their respective sections in this chapter. CSP = concentrating solar power; REEs = rare earth elements; PGM = platinum group metals. * In this report, aluminium demand is assessed for electricity networks only and is not included in the aggregate demand projections.

IEA The Role of Critical Minerals in Clean Energy Transitions (windows.net)

Some Critical Metals in Seabed Minerals

Critical mineral needs for clean energy technologies

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminium
Solar PV	●	●	●	●	●	●	●	●	●
Wind	●	●	●	●	●	●	●	●	●
Hydro	●	●	●	●	●	●	●	●	●
CSP	●	●	●	●	●	●	●	●	●
Bioenergy	●	●	●	●	●	●	●	●	●
Geothermal	●	●	●	●	●	●	●	●	●
Nuclear	●	●	●	●	●	●	●	●	●
Electricity networks	●	●	●	●	●	●	●	●	●
EVs and battery storage	●	●	●	●	●	●	●	●	●
Hydrogen	●	●	●	●	●	●	●	●	●

Relative importance of minerals for a particular clean energy technology: High: ● Moderate: ● Low: ●

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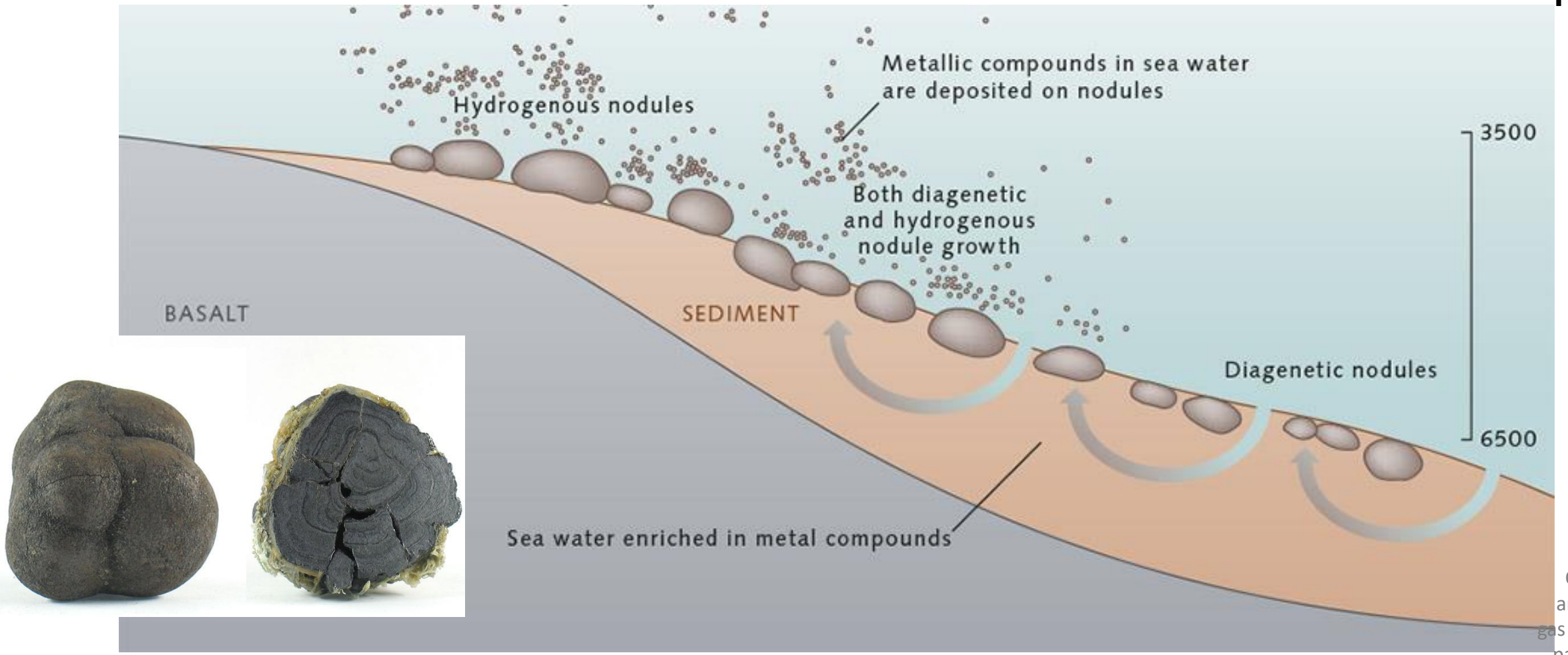
IEA The Role of Critical Minerals in Clean Energy Transitions (windows.net)

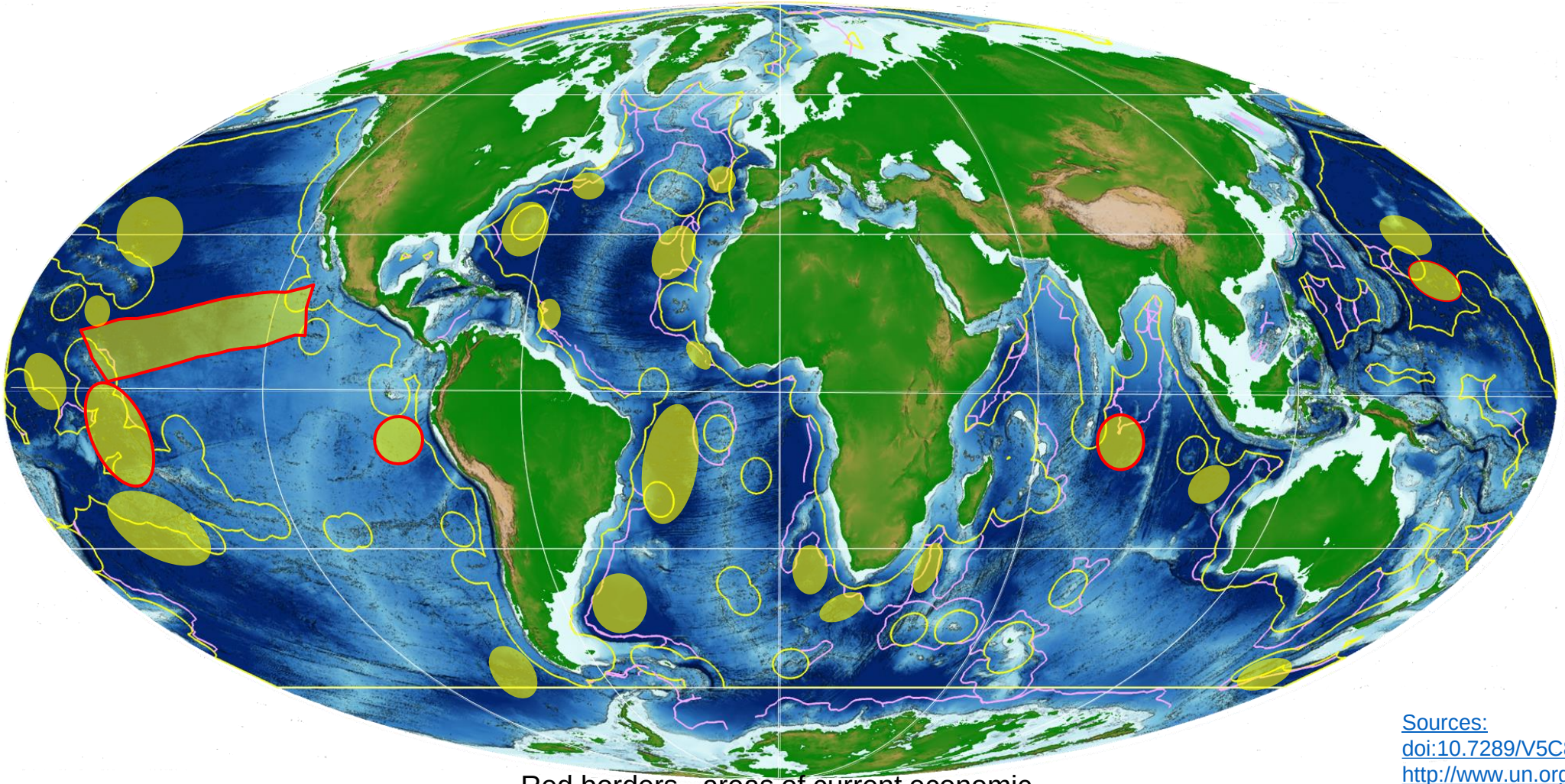
Polymetallic Nodules [Mn, Ni, Co, Cu (Li, Ti)]



World Ocean Review, http://worldoceanreview.com/en/

Oil and gas as part of the solution for energy

Favourable areas for PM nodules

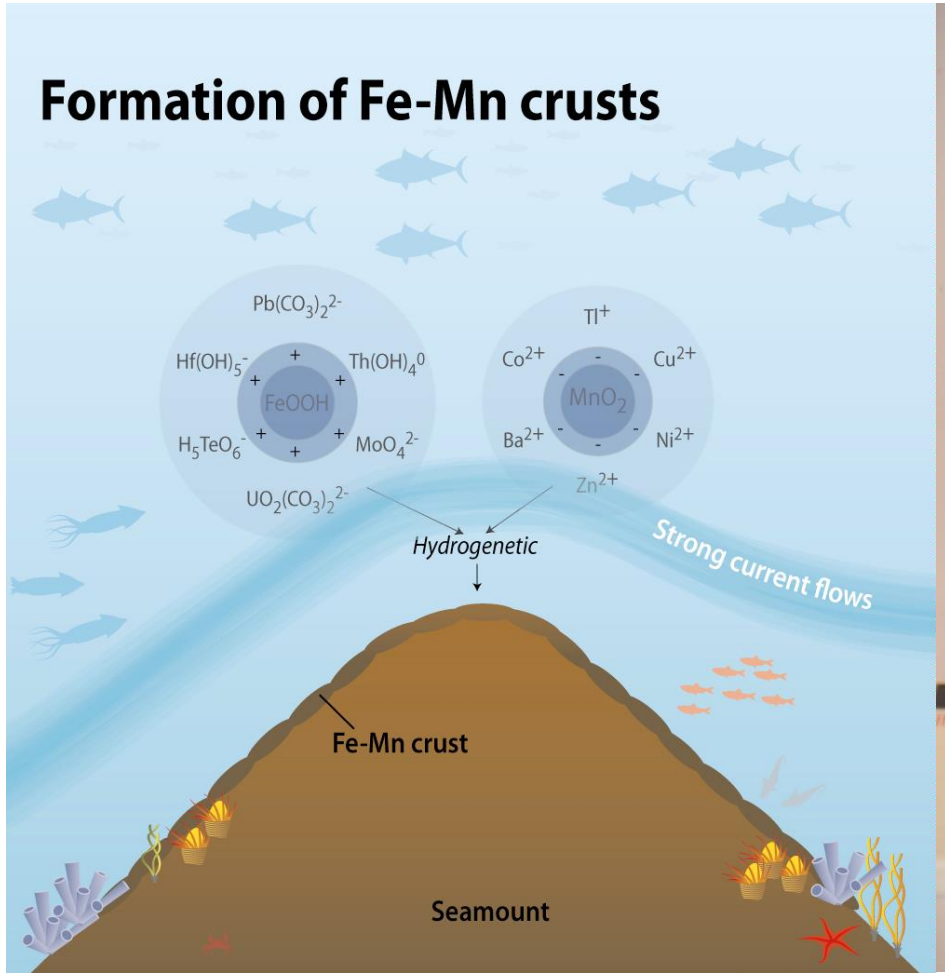


Red borders - areas of current economic interest

Sources:
doi:10.7289/V5C8276M, ETOPO1
http://www.un.org/depts/los/index.htm
Global Maritime Boundaries Database
T. Khun et al., 2017

Polymetallic Crusts

[Mn, Co, Cu, REE (Ti, Pt, V)]

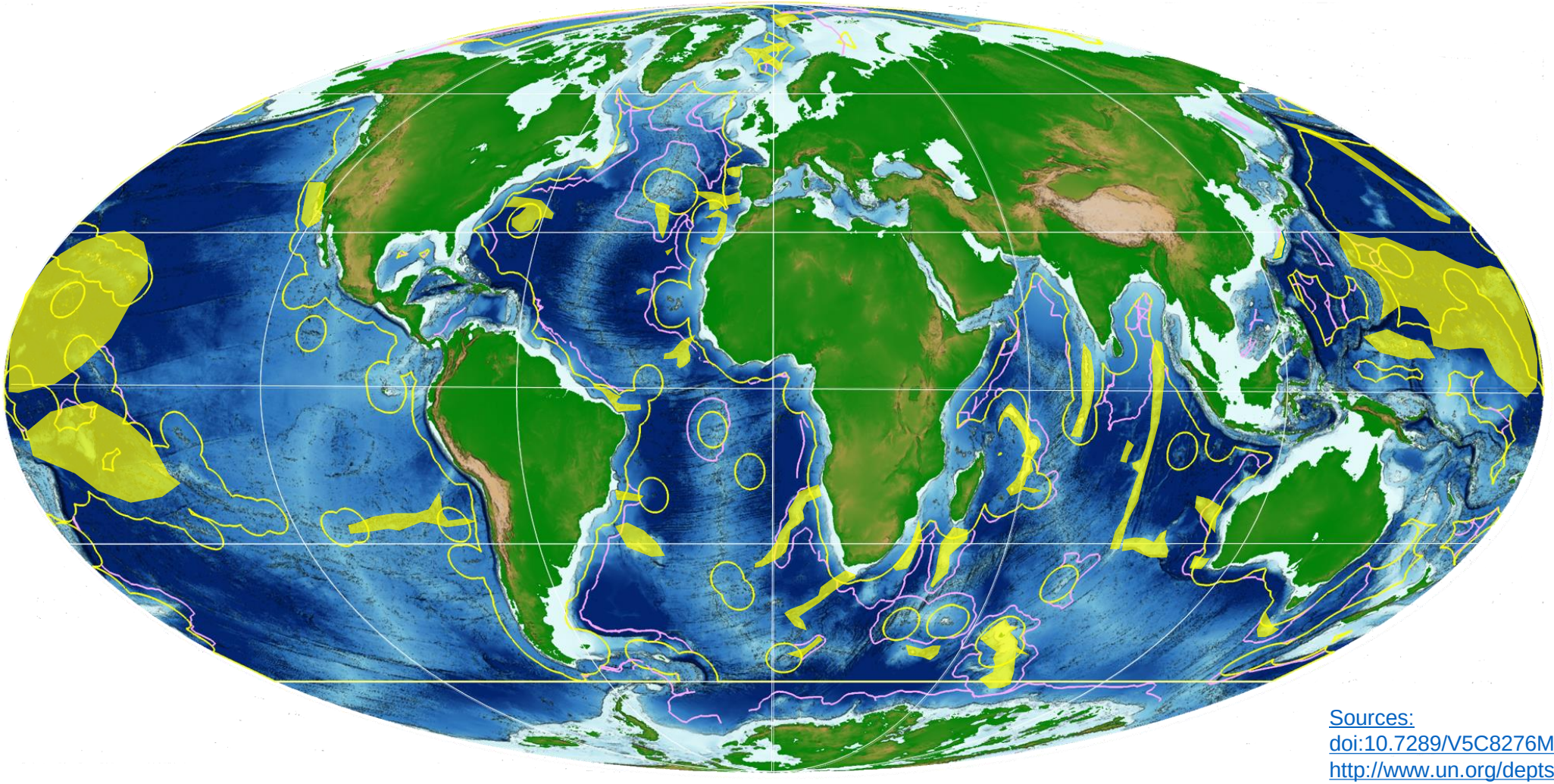


J.R. Hein 2004

Norwegian Petroleum Directorate

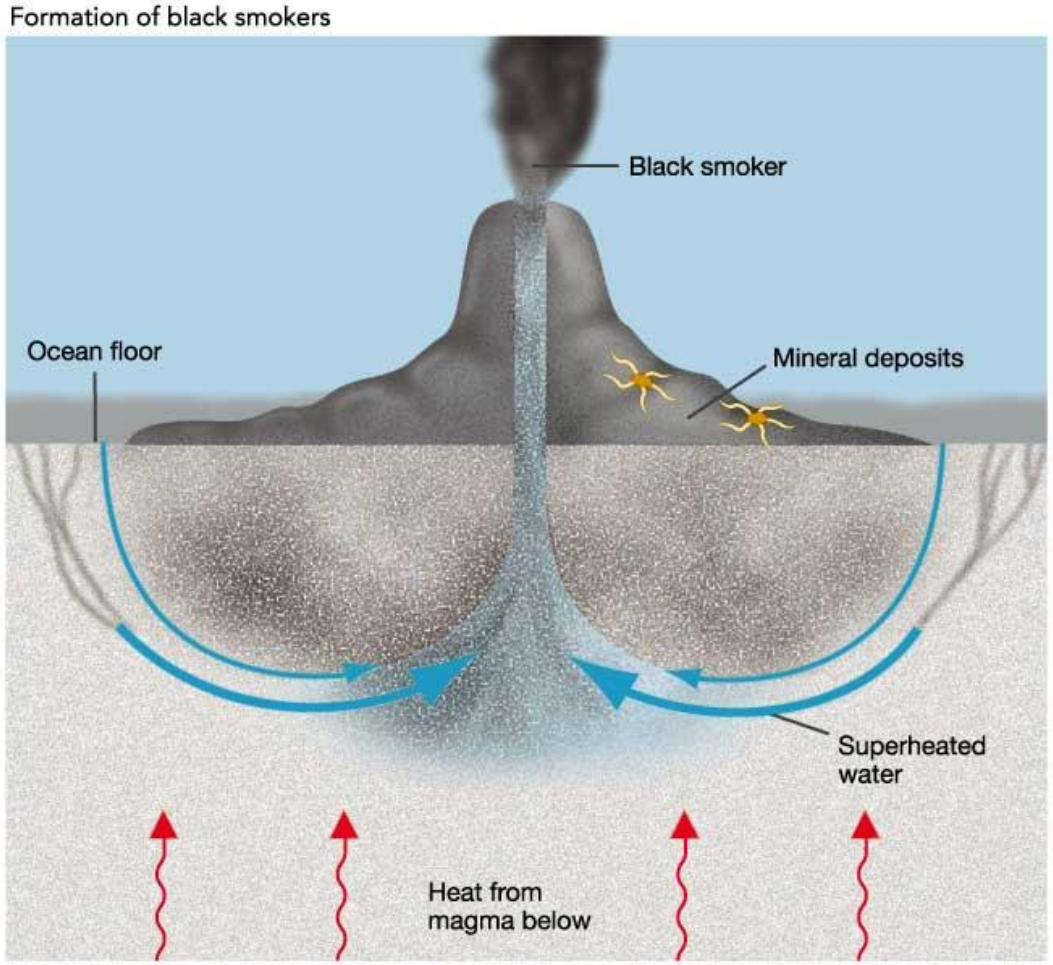
of the soluti on for energ y

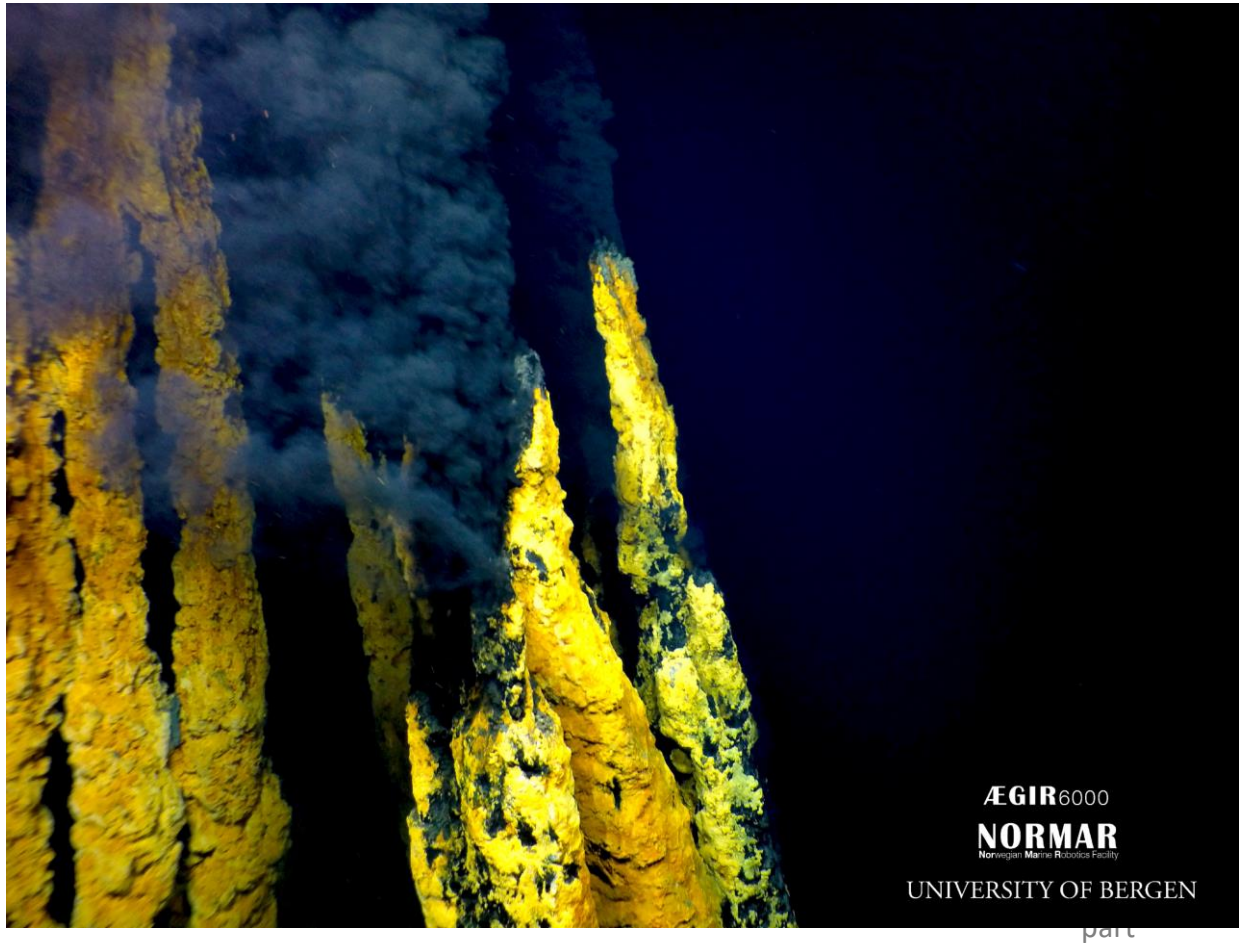
Favourable areas for PM crusts



Sources:
doi:10.7289/V5C8276M, ETOPO1
http://www.un.org/depts/los/index.htm
Global Maritime Boundaries Database
P.E. Halbach et al., 2017

Polymetallic Sulphides [Cu, Zn, Au, Ag (Pb, Co)]

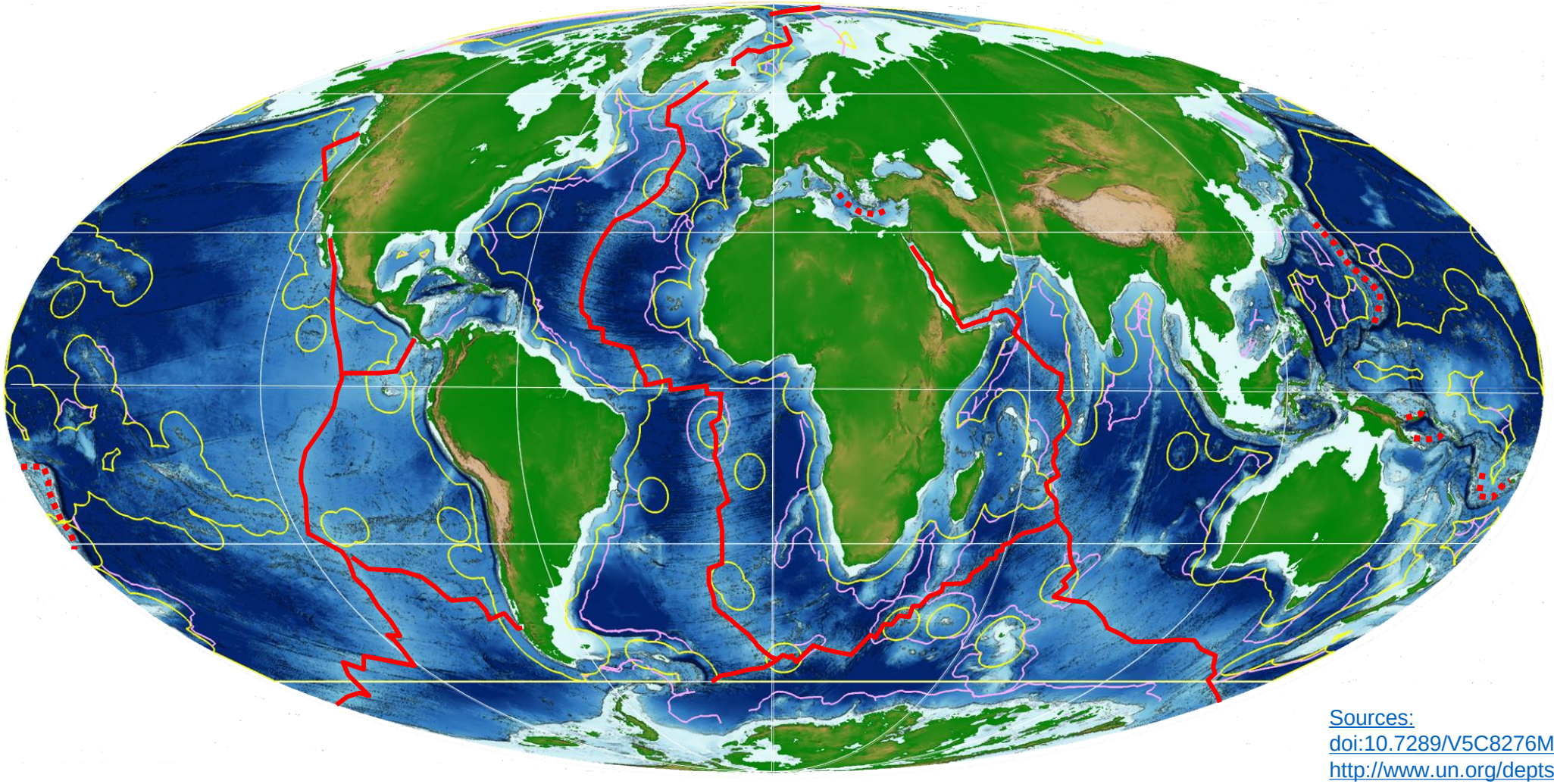




Black smokers or hydrothermal vent, Formation of black smokers (karadimov.info)

part of the solution for energy

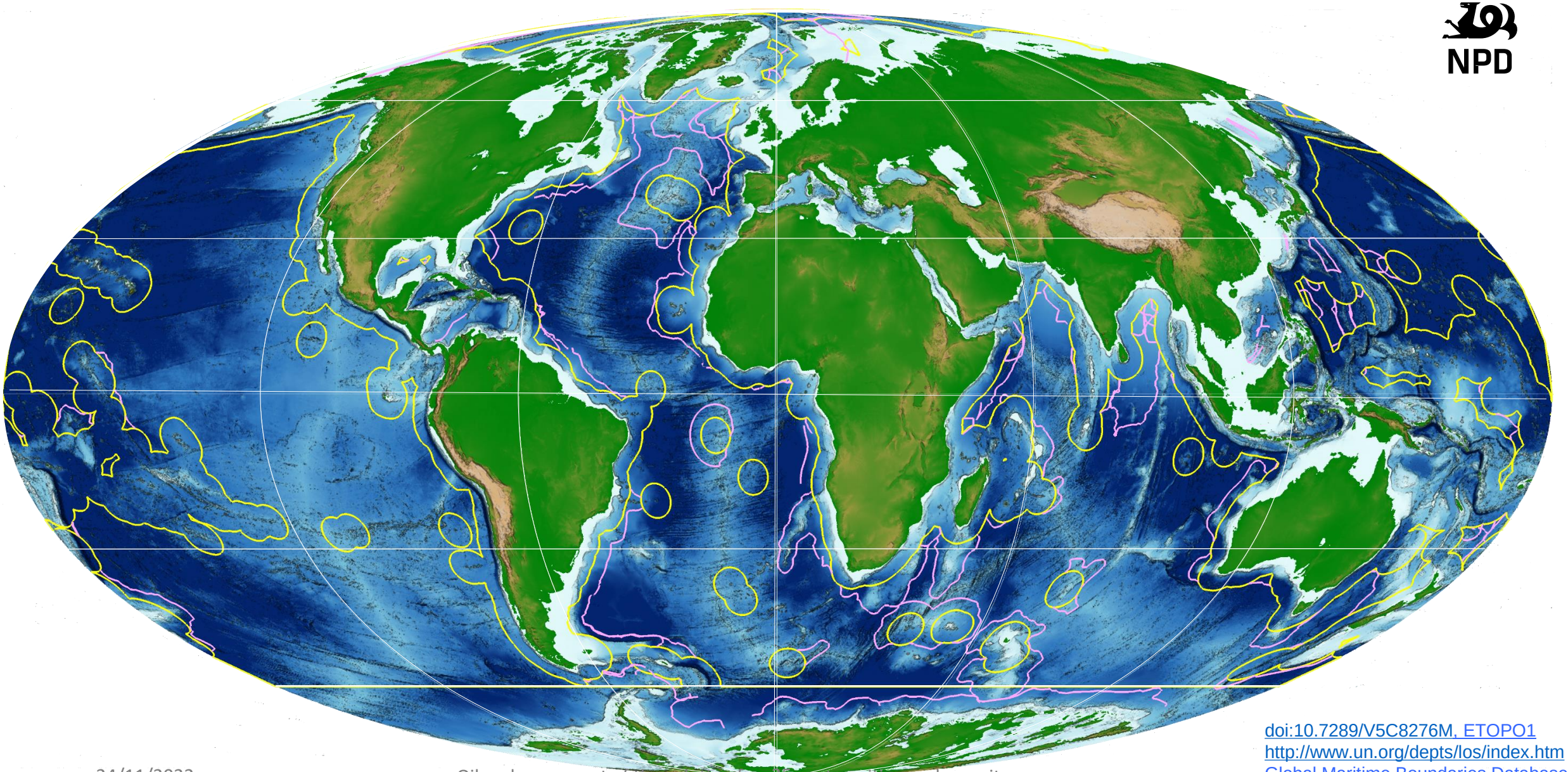
Favourable areas for hydrothermal sulphide deposits



Sources:
doi:10.7289/V5C8276M, ETOPO1
http://www.un.org/depts/los/index.htm
Global Maritime Boundaries Database

Seabed Jurisdiction and Resource Management

EEZ and Continental Shelf limits



doi:10.7289/V5C8276M, ETOPO1
http://www.un.org/depts/los/index.htm
Global Maritime Boundaries Database

Seabed Jurisdiction areas

- Percentage of total world ocean seabed:

The International Seabed (The Area)	53 %
The Continental Shelf	46 %

(the EEZ 39 %)

Source - http://www.grida.no/publications/shelf-last-zone/

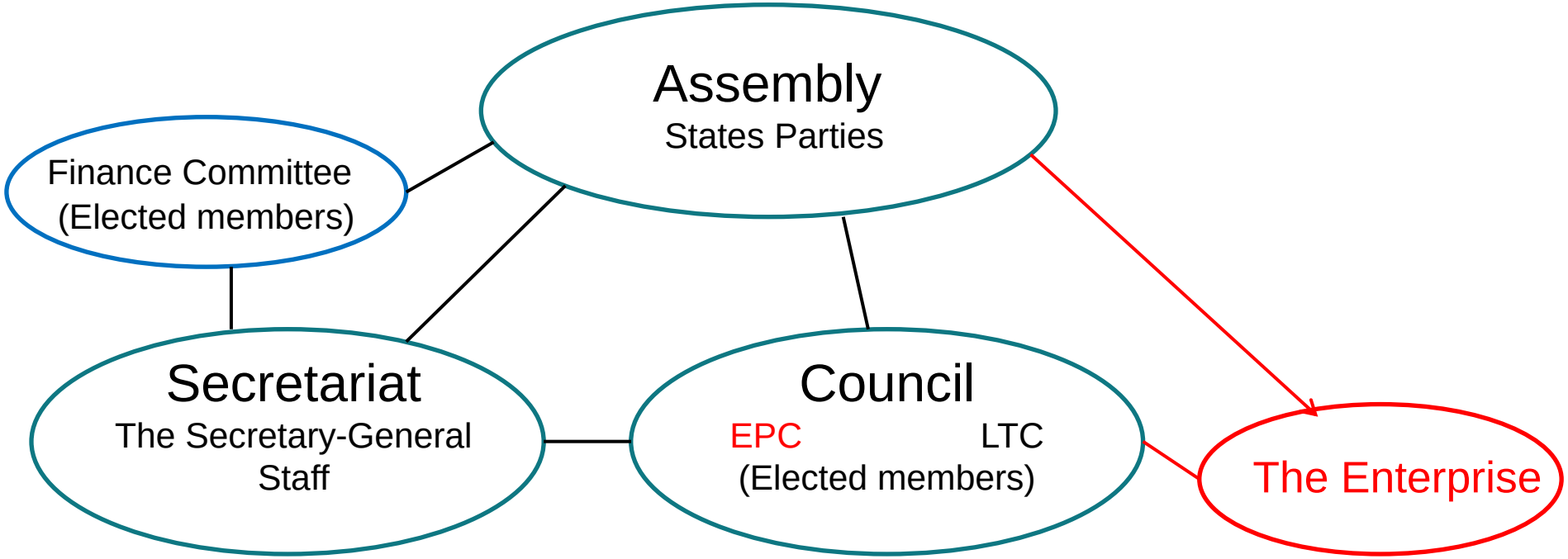
The Area

The International Seabed

The International Seabed Authority (ISA)

Oil and gas as part of the soluti on for energ y

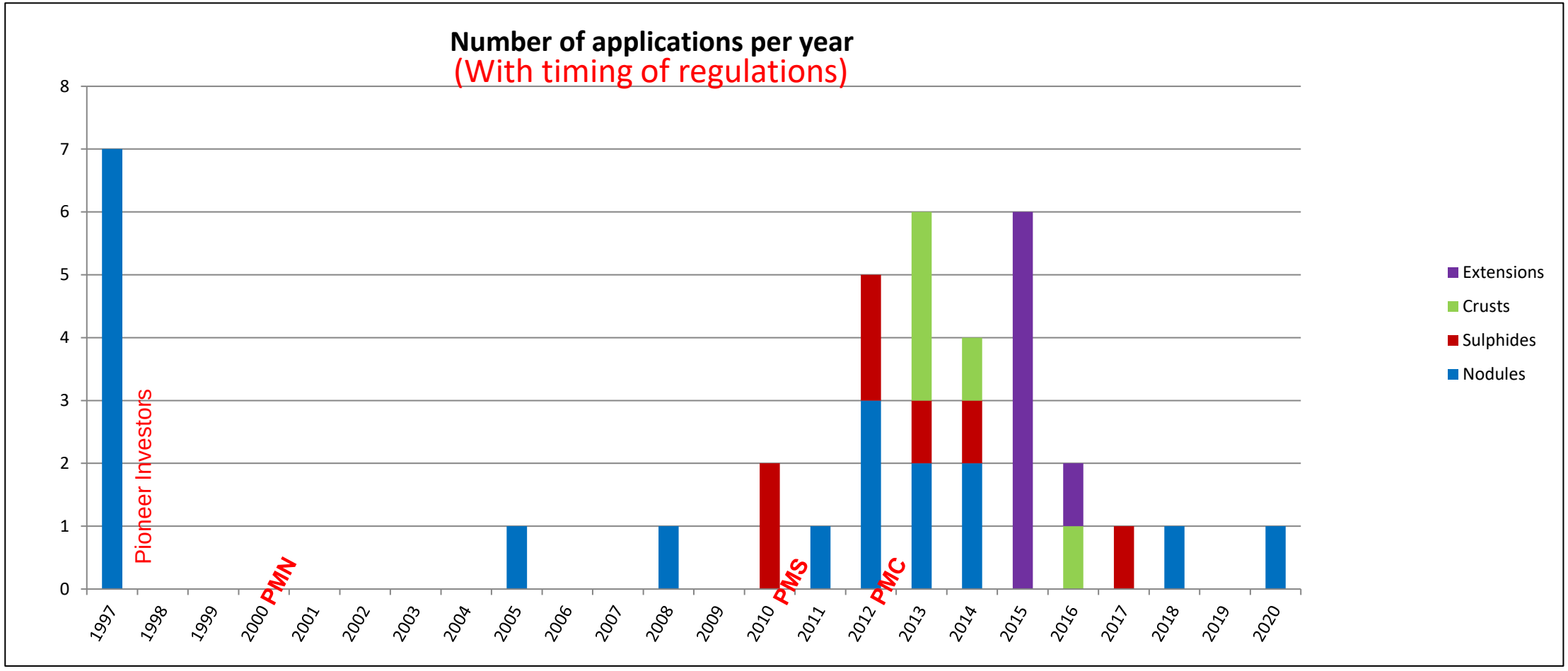
The International Seabed Authority



EPC - The Economic Planning Commission
LTC - The Legal and Technical Commission

Oil and gas as part of the solution for energy

Applications for international exploration contracts



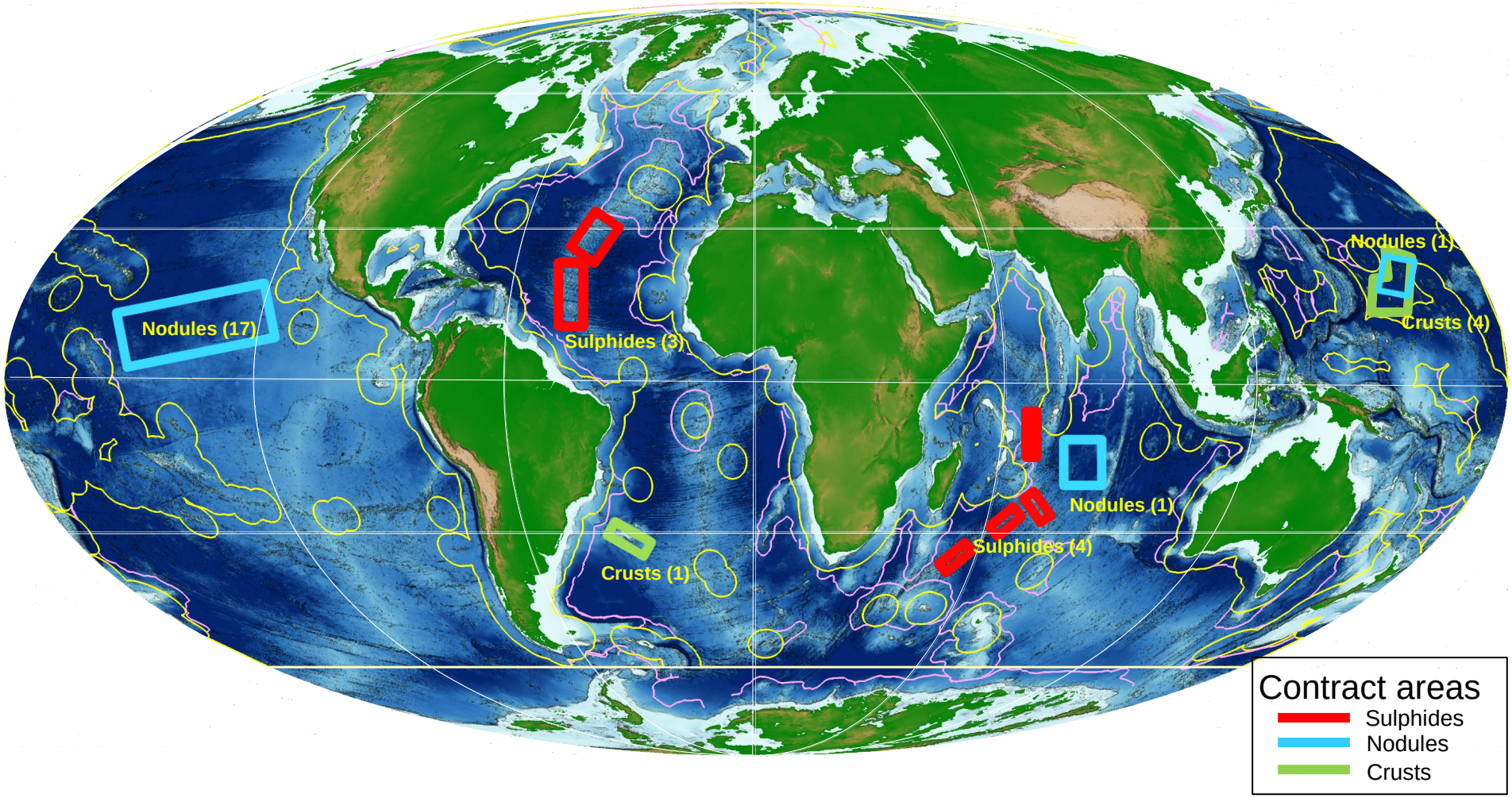
International Seabed Authority (ISA) – Exploration Contracts

- Polymetallic nodules 19
- Polymetallic sulphides 7
- Polymetallic crusts 5

- Contracts total 31

- ISA is currently preparing regulations for development and production

Areas of exploration contracts under ISA



States sponsoring exploration

- Cook Isls
- Jamaica
- Kiribati
- Nauru
- Singapore
- Tonga

- Brazil
- China
- India
- Japan
- South-Korea

- Belgium
- France
- Germany
- Poland
- Russia
- UK

The Continental Shelf

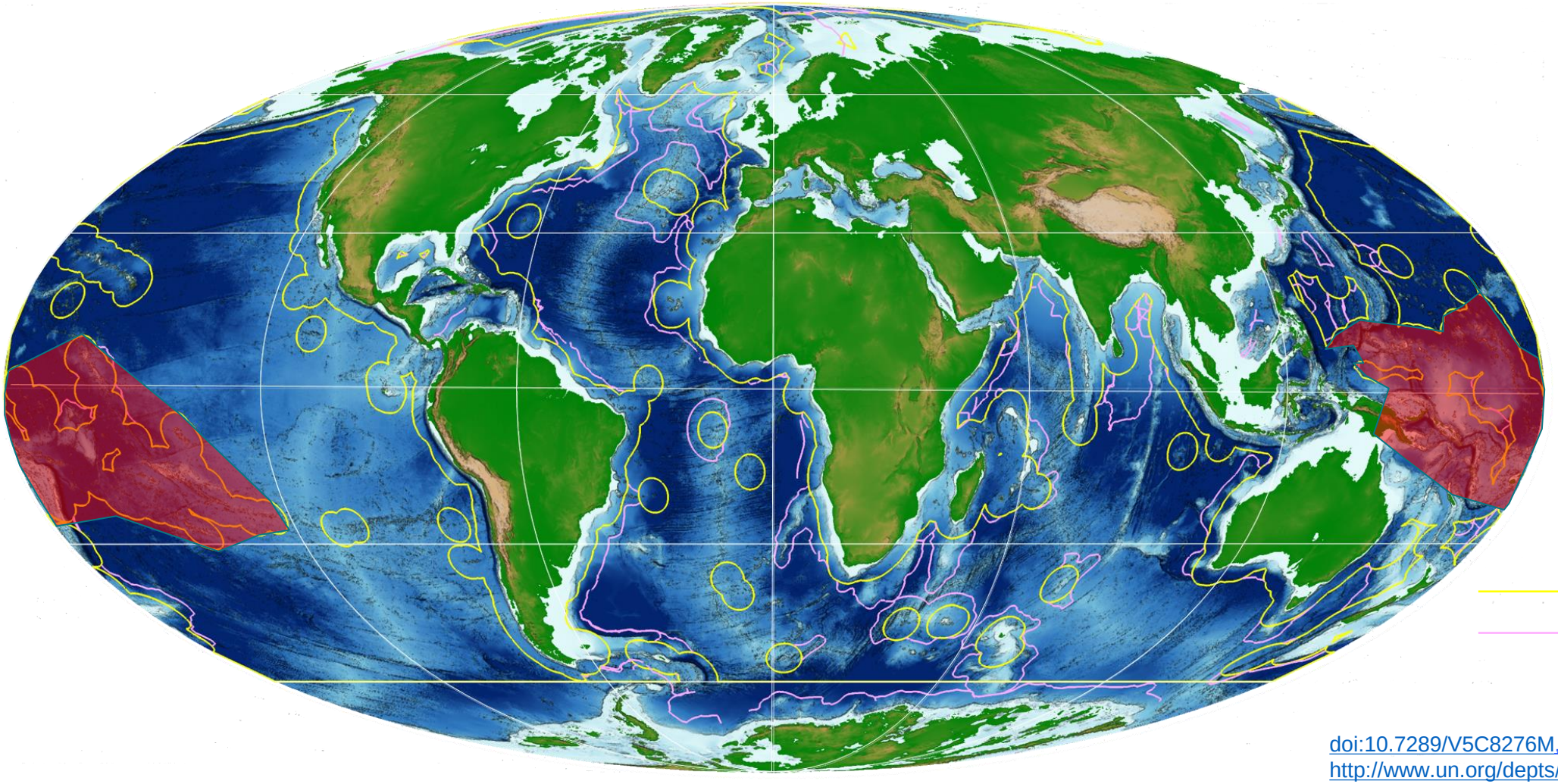
The Seabed of Coastal States

Percentage of favourable mineral areas and total ocean area

	Nodule areas	Crust areas	Sulphide areas	World Ocean seabed area
The Area	81	46	58	53
The CS	19	54	42	47
(The EEZ)	(14)	(44)	(36)	(39)

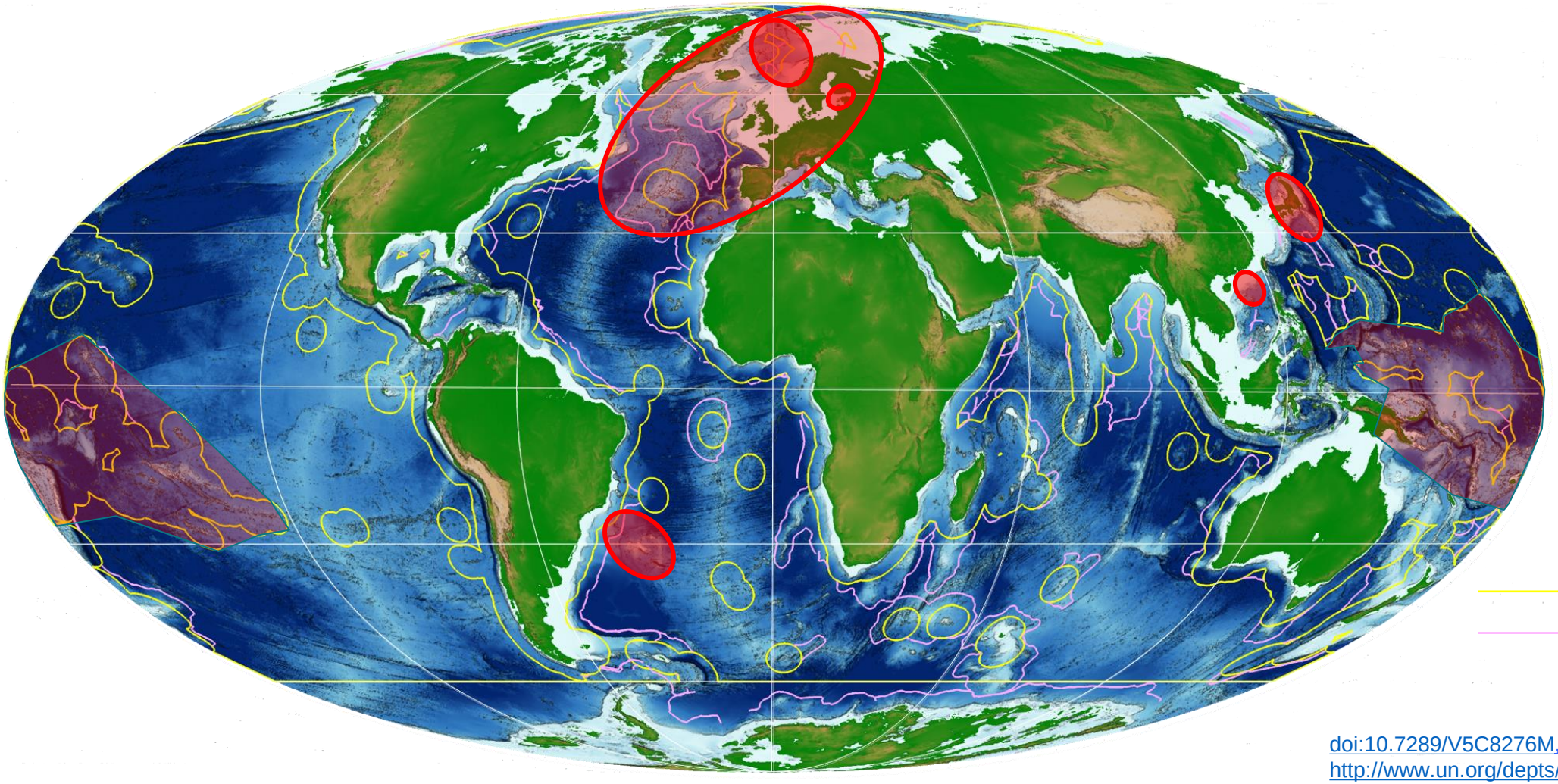
Petersen et al., 2016, Marine Policy

Small Island Pacific States – the Continental Shelf



doi:10.7289/V5C8276M, ETOPO1
http://www.un.org/depts/los/index.htm
Global Maritime Boundaries Database

Areas of activity – the Continental Shelf



doi:10.7289/V5C8276M, ETOPO1
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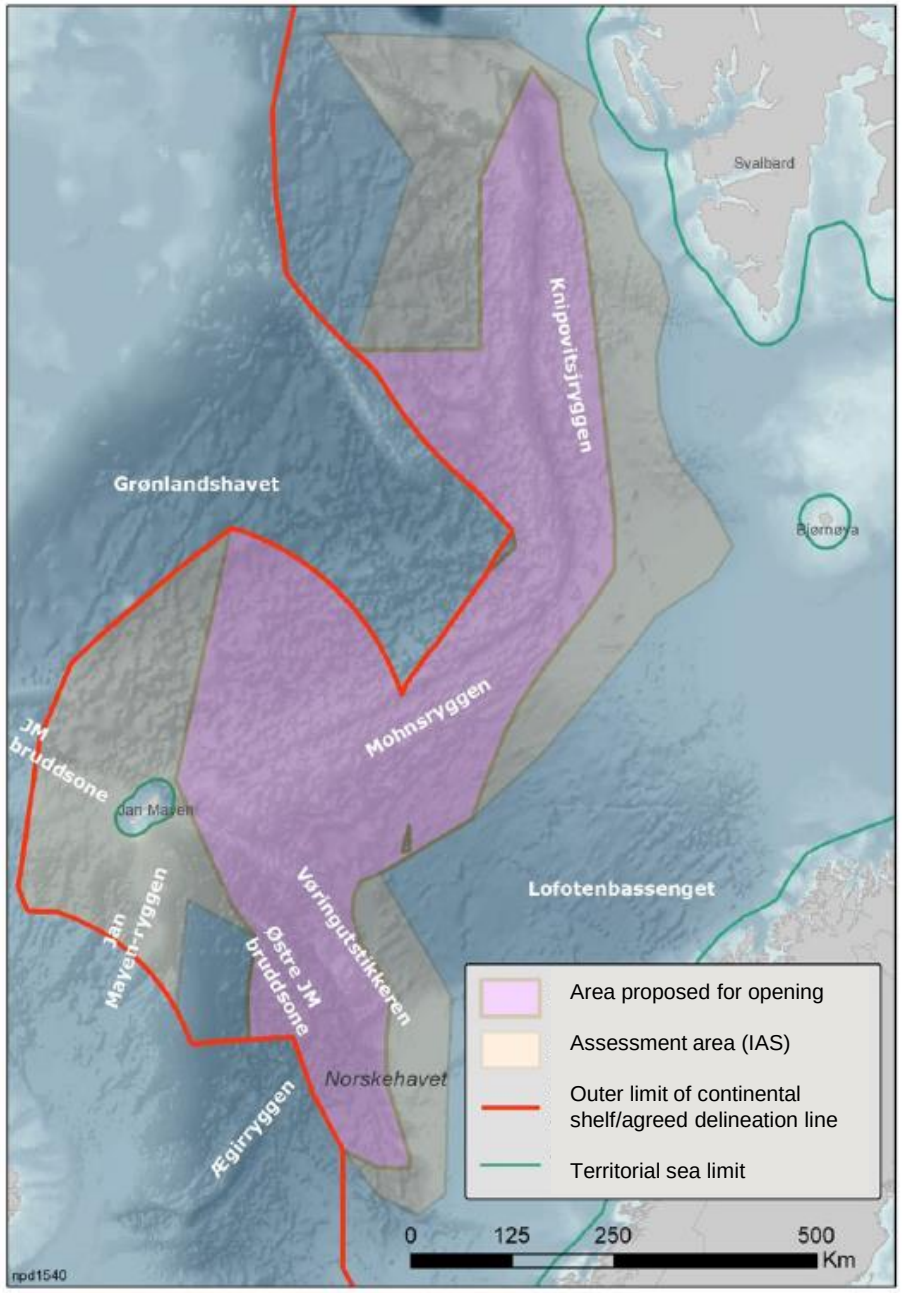
Global Maritime Boundaries Database



Norway – Continental Shelf

NPD

- Marine scientific research from 1999
- Government data acquisition cruises from 2018
- Subsea Minerals Act 2019
- Initiated opening process in 2020
- Impact assessment study (IAS) 2021-2022
- IAS on public consultation 27.10.2022 – 27.01.2023

Thank you for your attention!

npd.no
factpages.npd.no/no
norskpetroleum.no