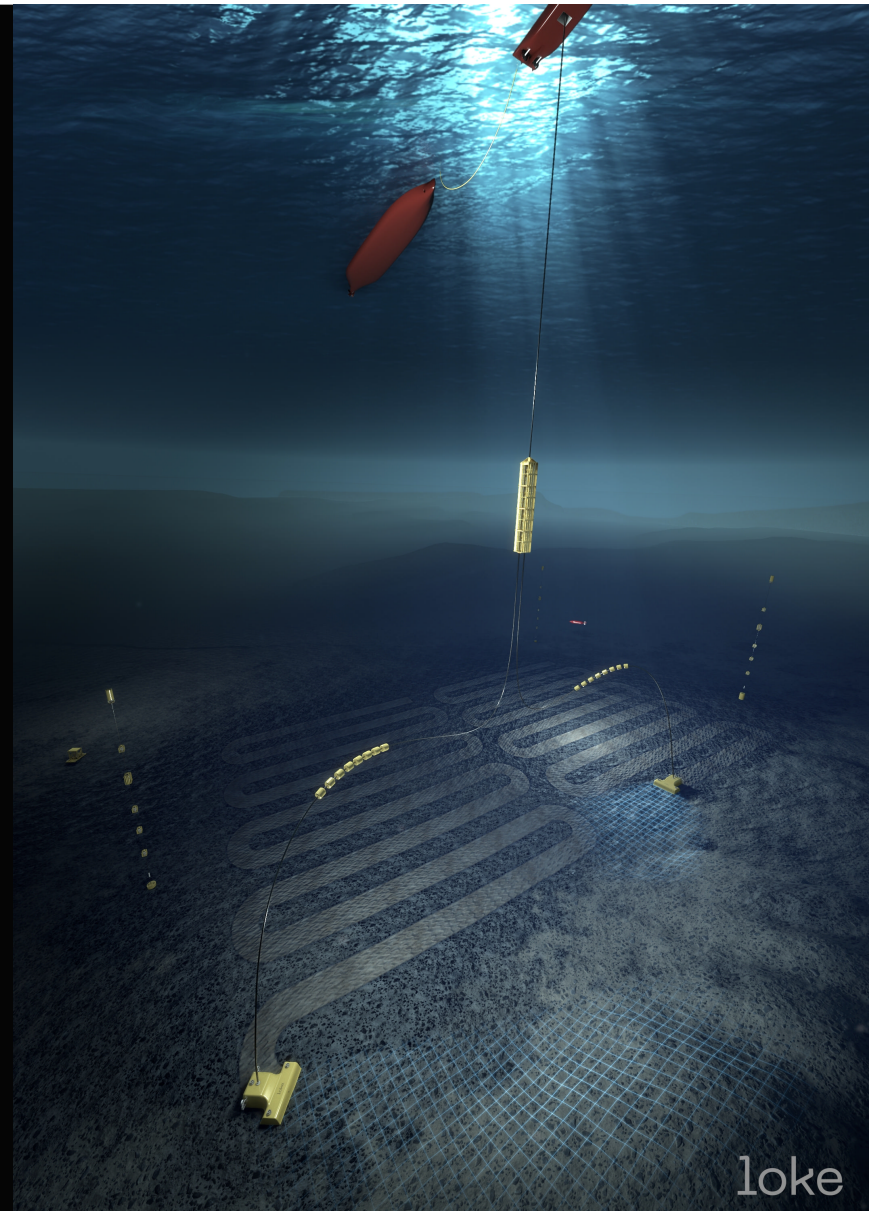


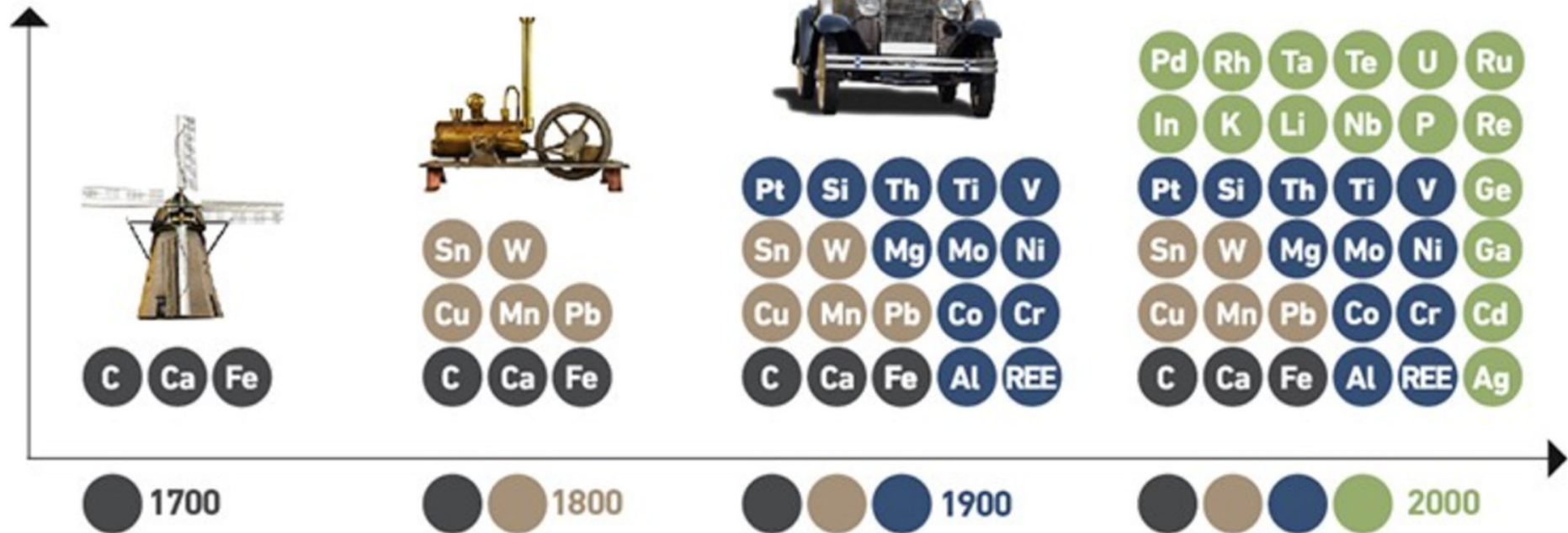
# Providing sustainable sourcing of battery minerals

FFU Seminar 2023  
Blue Intelligence

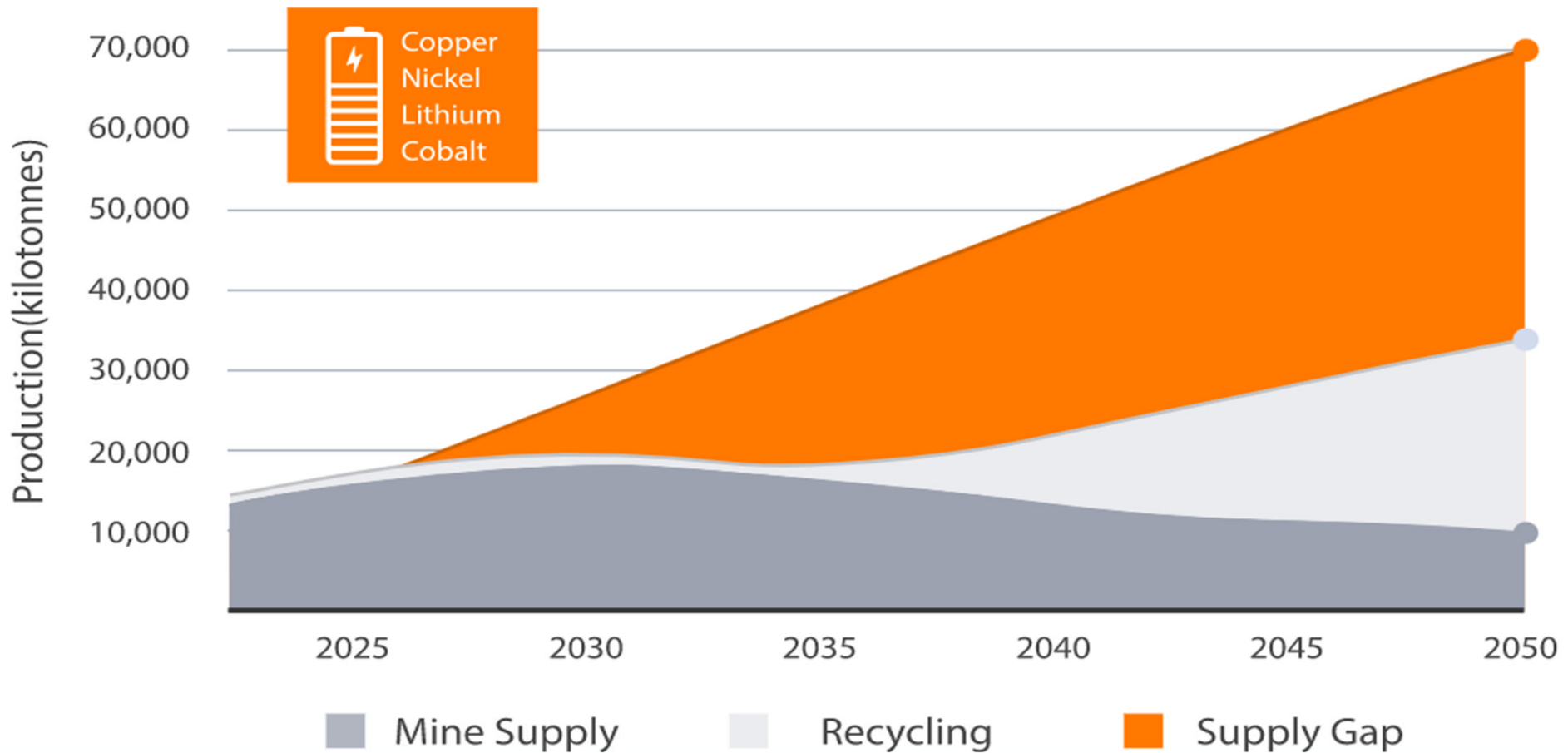
Tore Halvorsen  
Loke Marine Minerals AS

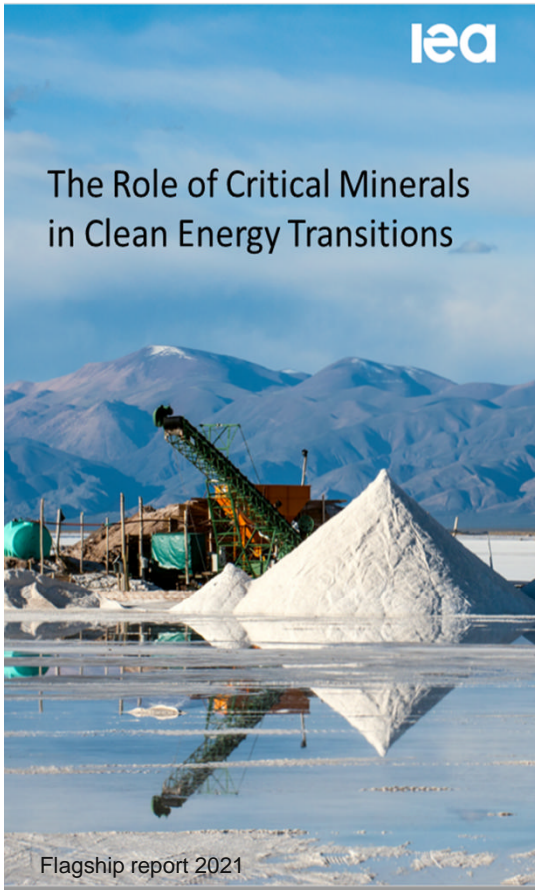


# The Future is Metallic



# Demand and Supply - Please Mind the Gap





Critical Minerals play a key role in the green energy transition

# The Green Energy transition comes with a high geopolitical and ESG risk

China is doing the dirty laundry for the green energy transition



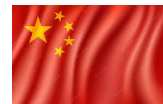
*"The Middle East has oil; China has rare earths."*  
Dèng Xiǎopíng 1992



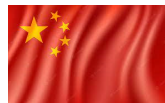
End users



Battery factory



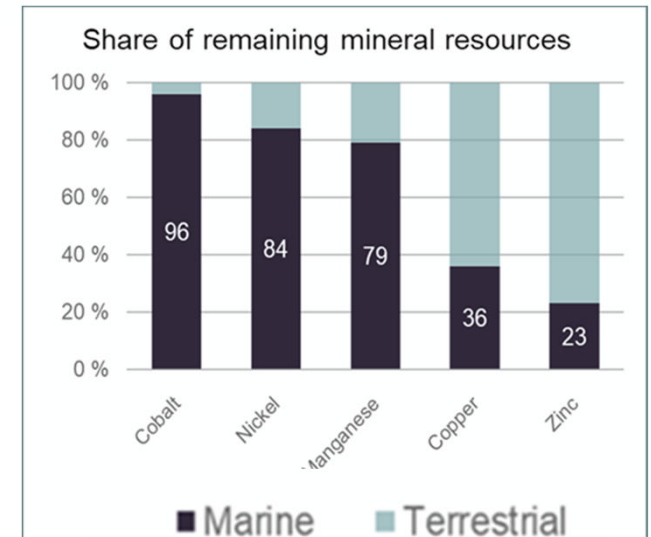
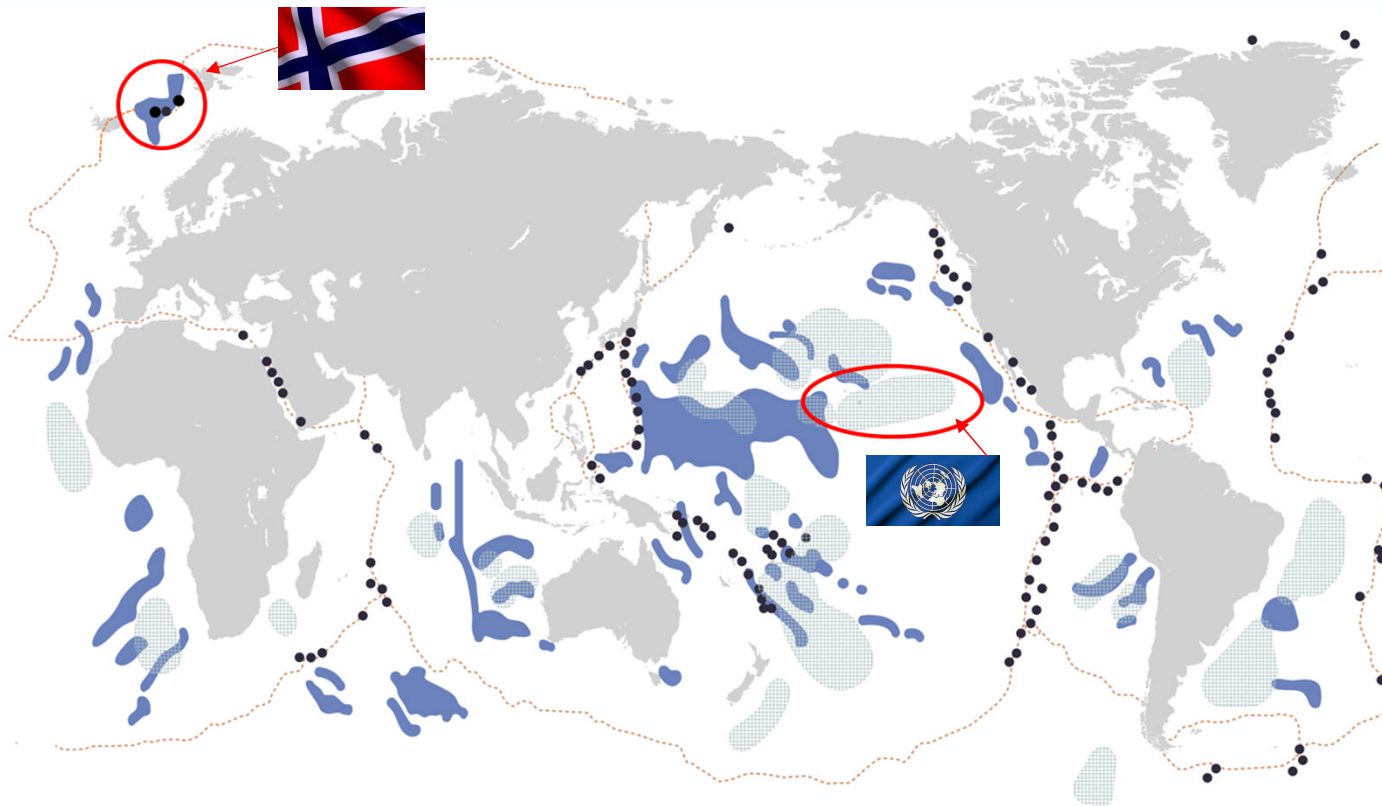
Processing



Mining

# Loke's Twin Engine Approach – Crust / Norway and Nodules / Internationally

Deep Sea Minerals holds the largest remaining undeveloped resources of several of the critical minerals



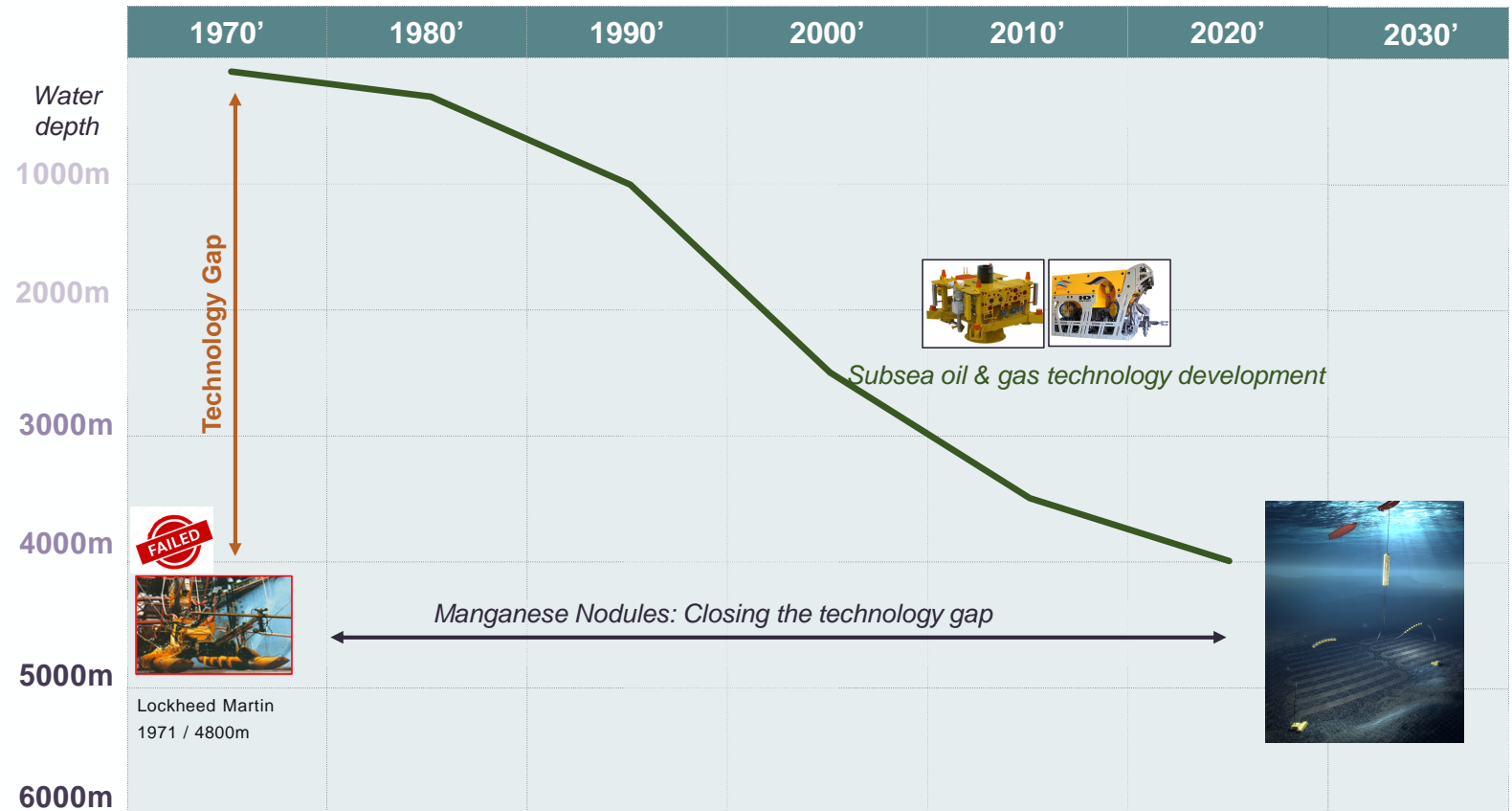
- Loke Focus area – Norway / Clarion Clipperton Zone ISA/FN
- Manganese Nodules
- Manganese Crust
- SMS

# Technology gap closed through decades of subsea oil & gas development

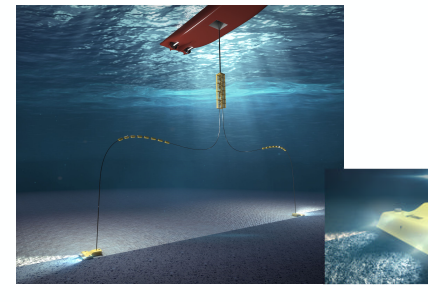
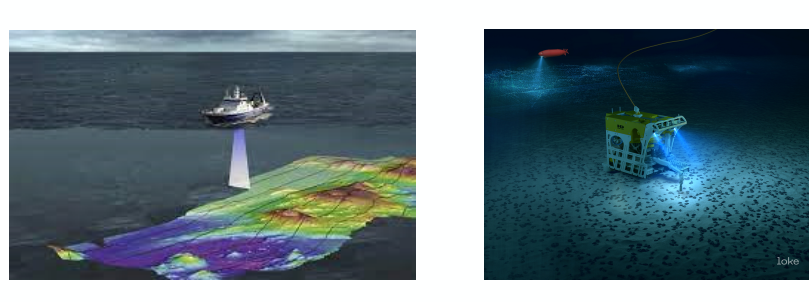
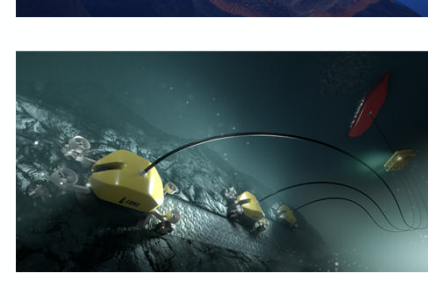
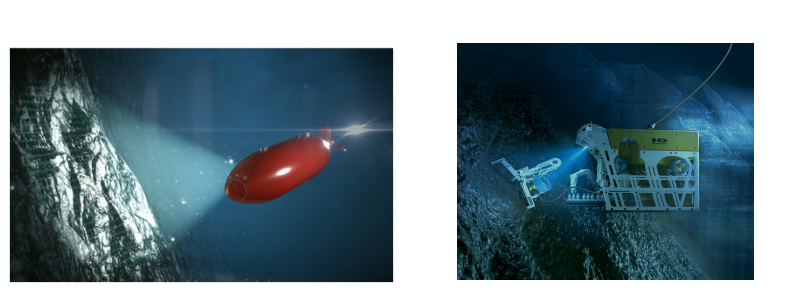
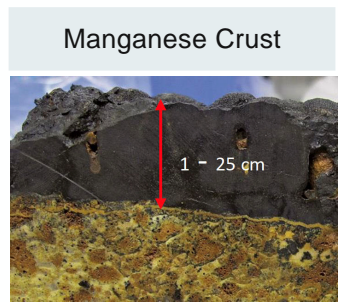
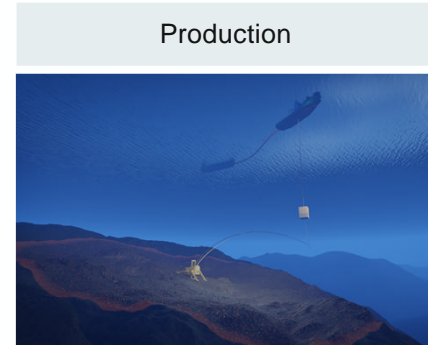
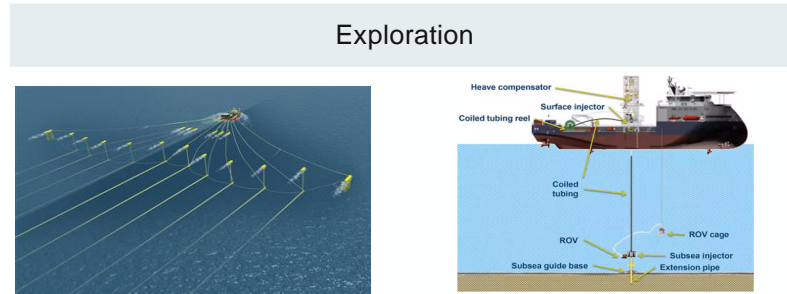
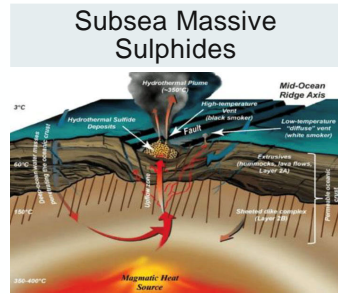
Deep water mining technology – strong similarity to deep water oil & gas technology

**Subsea Oil & Gas industry spent over 40 years qualifying reliable technology for 6000m wd:**

- Controls and communication
- Sealing and penetration systems
- Remote operation and monitoring
- Redundancy design for long term exposure (25-30 yrs)
- Condition monitoring for preventive maintenance and operational uptime



# Deep Sea Minerals Technology Challenges - Overview







### Manganese Crust

### Exploration:

- AUV based “Fly By” thickness measurements by acoustics
- ROV based Manganese Crust coring system – successfully tested in 2 500 m water depths October2022

Manganese Crust – Production

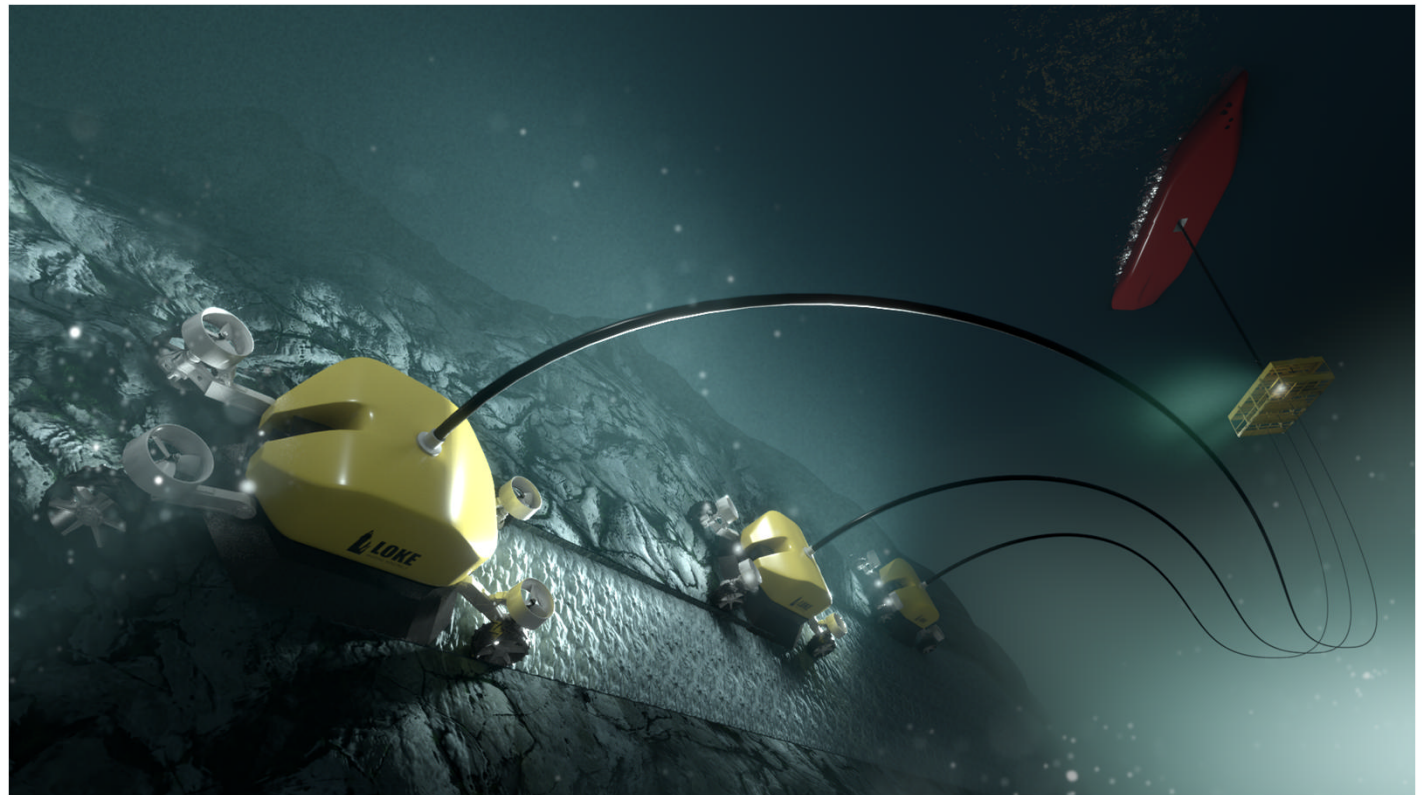
## Crust Cutting & Collection

Concept:

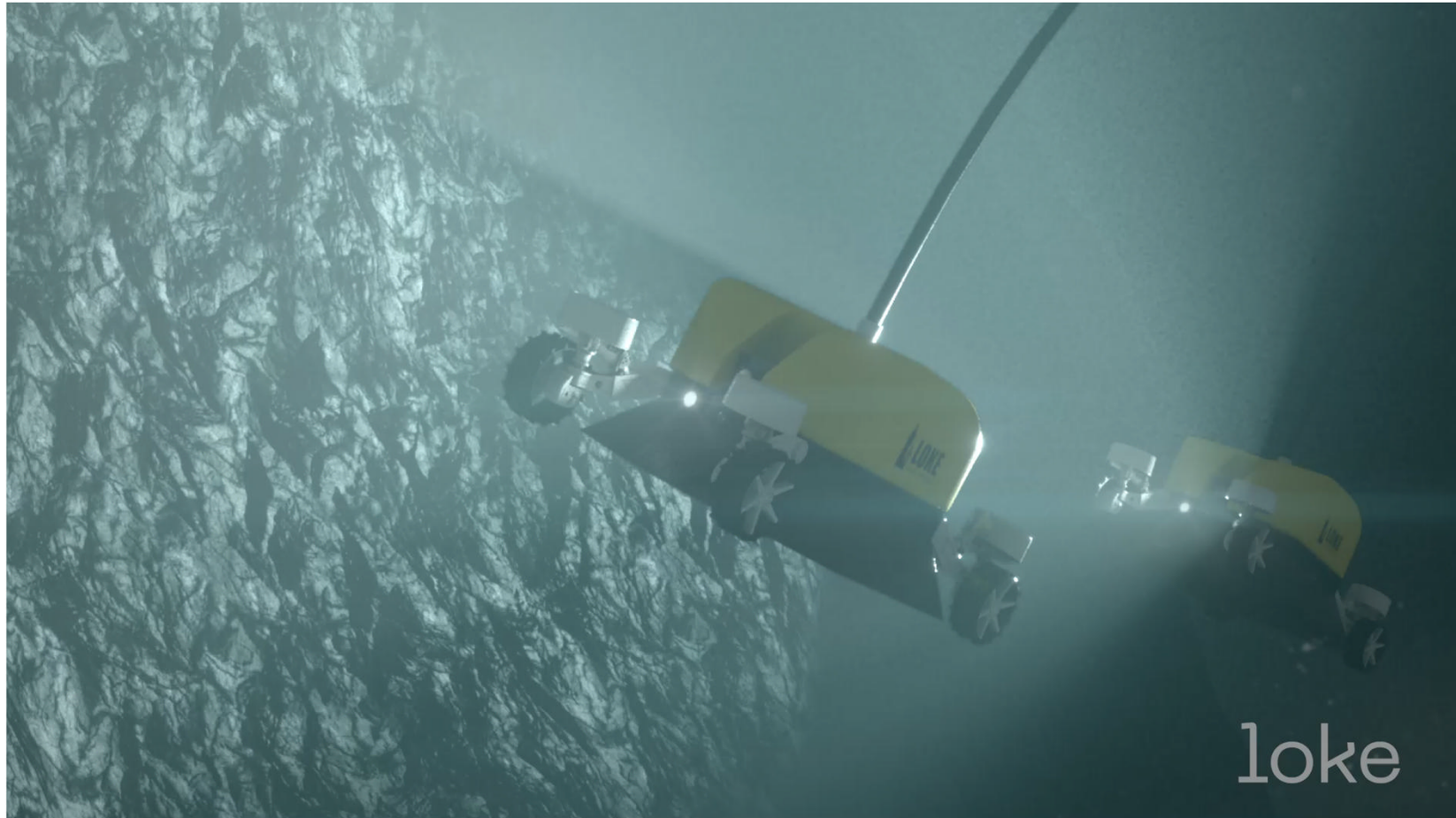
- Several smaller neutrally buoyant cutting & collection tools
- Enable operation on steep seamounts – up to 90 deg
- Autonomous operated – linked tracking/ navigation system

Status:

- Initial lab testing of cutter head completed
- Key input parameters established
- Patent filed



## Manganese Crust Harvesting

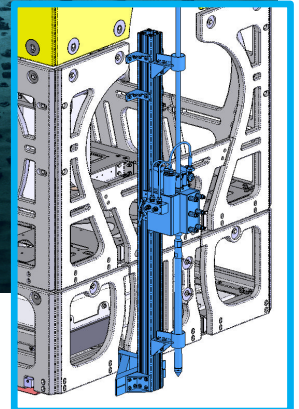
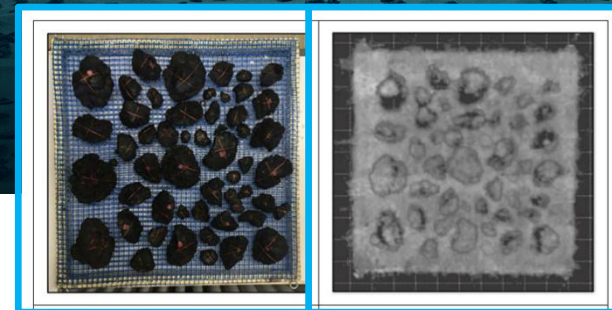
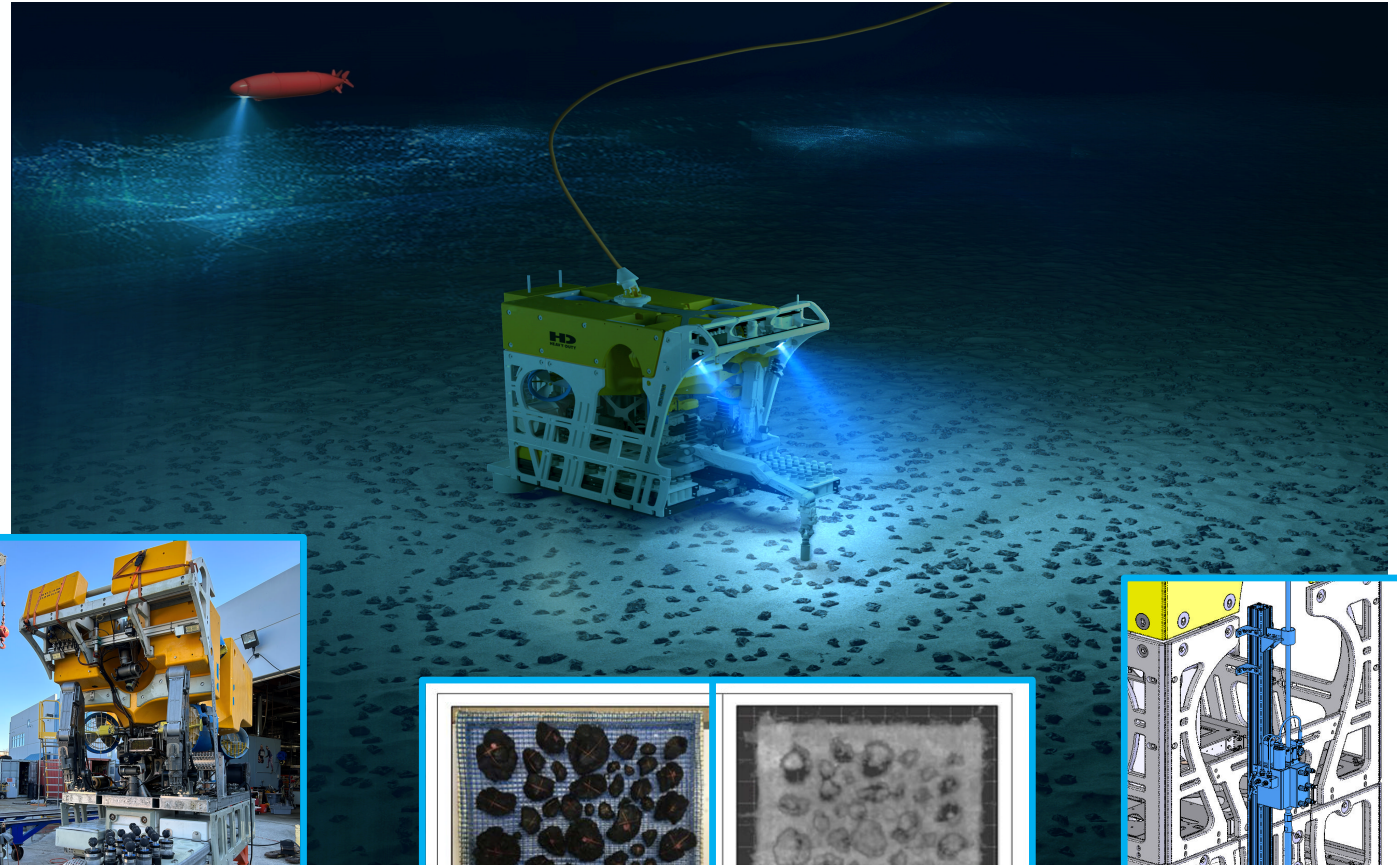


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# Manganese nodules Exploration

## Concept:

- Fully ROV based Exploration and Sampling tool
- Digital volumetric scanning of Nodules to determine Nodule Abundance (kg/m<sup>2</sup>)
- Collection of nodule samples – up to 100 sites
- Increased exploration efficiency with 5-10 times



## Nodule Harvesting



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## Manganese Nodules Production

- Mechanical nodule pick-up collection head with minimum seabed disturbance
- No sediments returned from Production Vessel
- Autonomous Collection Tools – no light pollution
- Free swimming Collection Tools – allowing easy repositioning to protect sensitive habitats
- Production capacity of 10 000 ton nodules per day



1.1%	1.3%	0.2%	29%
29 <b>Cu</b> Copper 63.546	28 <b>Ni</b> Nickel 58.693	27 <b>Co</b> Cobalt 58.933	25 <b>Mn</b> Manganese 54.938

# A new Industry for Norway - from Exploration to Battery Factories +++

← Loke →

← Norway →

Phase 1 – exploration, technology development & production

Phase 2 – Shipping & logistics

Phase 3 – midstream & downstream mineral off-take

Exploration	Offshore production system	Shipping	Onshore base and processing facility	Energy transition Metals
				
<ul style="list-style-type: none"> <li>• Environmental baseline studies</li> <li>• Remote/autonomous operations</li> <li>• Survey AUV/ROV</li> <li>• Resource/core sampling</li> </ul>	<ul style="list-style-type: none"> <li>• Production vessel</li> <li>• Vertical transportation system</li> <li>• Mineral collectors</li> </ul>	<ul style="list-style-type: none"> <li>• Shipment of ore minerals from production vessel to onshore base</li> <li>• Decarbonized operation and transportation</li> </ul>	<ul style="list-style-type: none"> <li>• Onshore base/terminal for mineral unloading</li> <li>• Processing of critical minerals with highest ESG rating</li> <li>• Nickel, Cobalt, Copper, Manganese and REE</li> </ul>	<ul style="list-style-type: none"> <li>• Energy storage and battery producers</li> <li>• Energy grid infrastructure</li> <li>• Solar and offshore wind component industry</li> </ul>



Seeking New Partners

An aerial photograph of an offshore oil rig at sea. The rig is a large green and blue vessel with a prominent derrick. Several other smaller vessels are visible in the distance. The sky is overcast, and the water is dark. A semi-transparent dark blue curved line separates the surface view from a 3D visualization of the rig's seabed layout below. The seabed layout shows a complex network of yellow lines representing the rig's structure and various components.

[www.lokemm.com](http://www.lokemm.com)