Angling for Amperage

Deep Sea Mining for Critical Minerals

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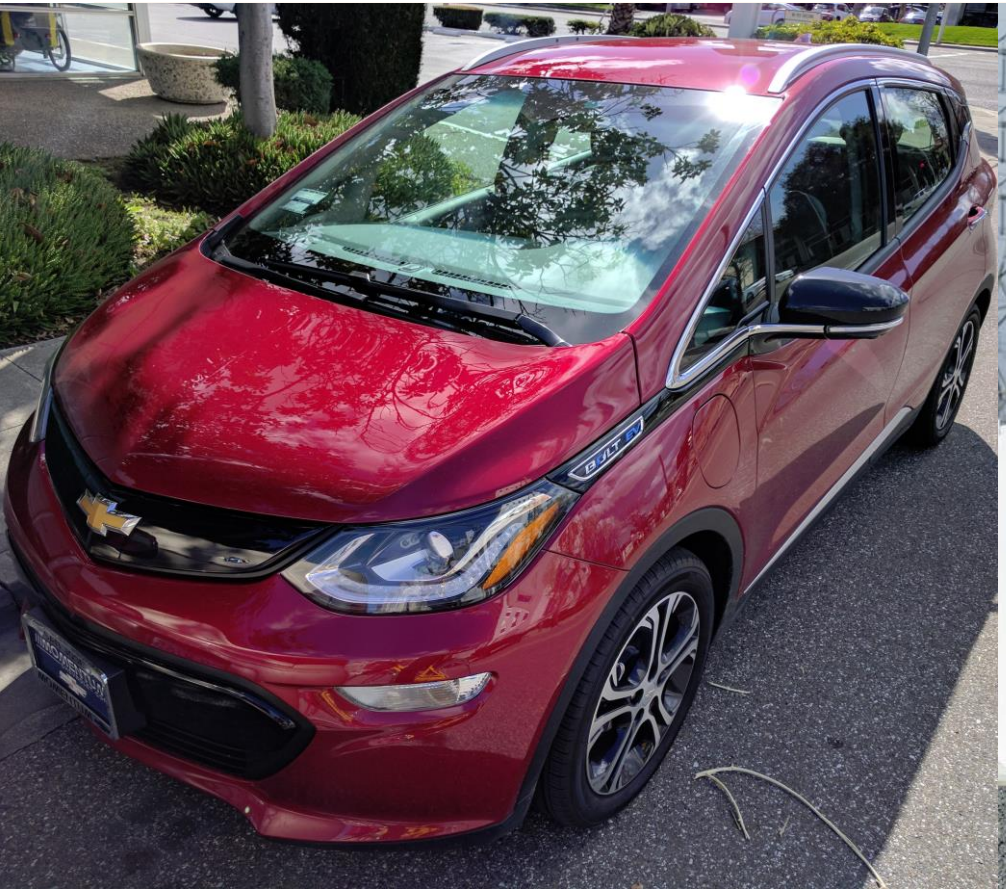
Aurora, CO
July 9th 2019

What do these three have in common?



Chevy Bolt

Miraloma Substation (80 kWh)

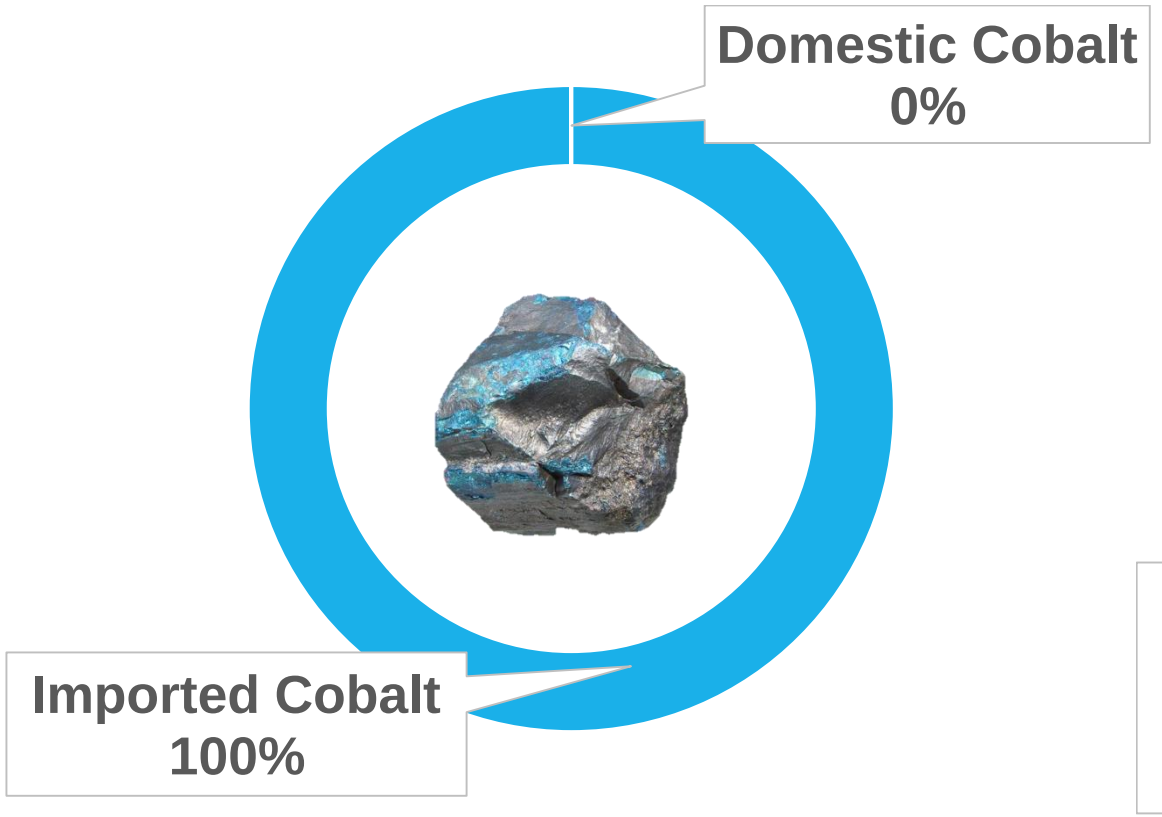
5MW Wind Turbine

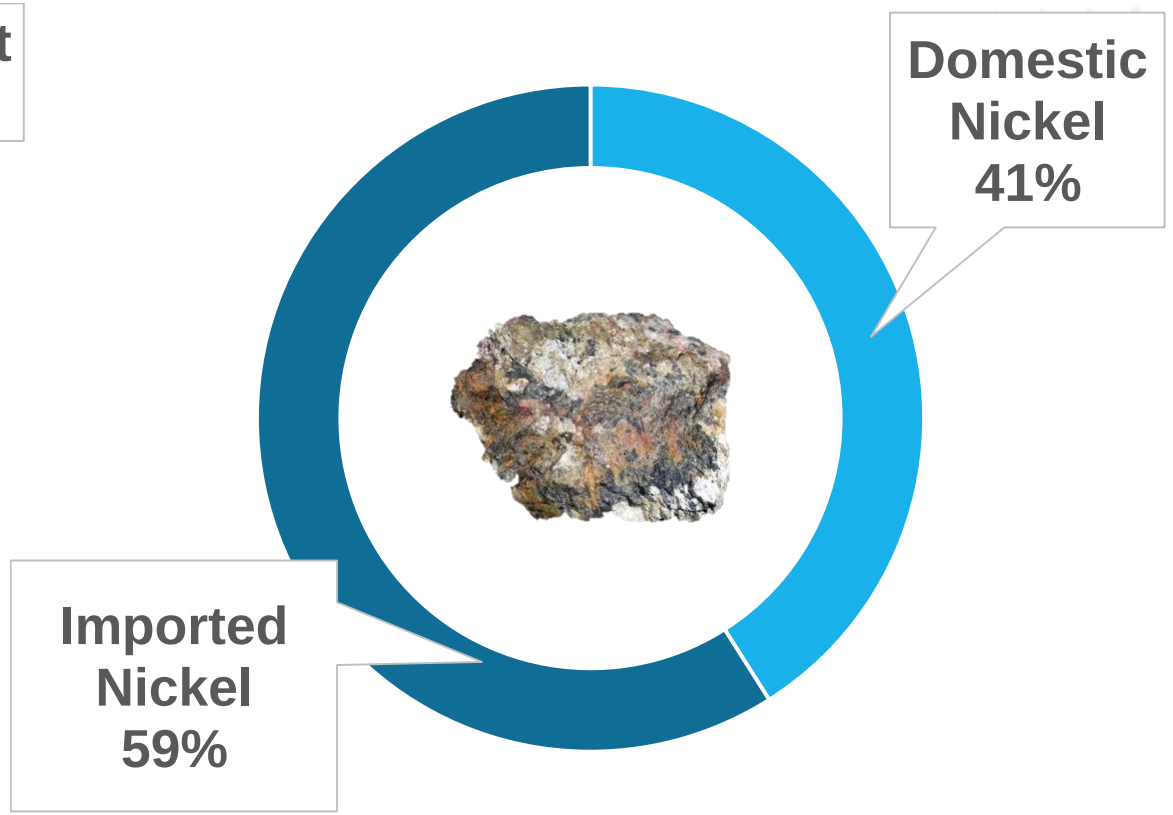
They all contribute to reduced emissions

Their adoption is rapidly accelerating

They all *require* critical minerals such as Cobalt, Nickel and Rare Earths

Access to Critical Minerals





https://www.indiamart.com/proddetail/high-grade-cobalt-ore-3054417162.html

Access to Critical Minerals

1000x more Cobalt needed than we can currently recycle!

Need large amounts of stably sourced minerals. Let's take a deep dive…

Clarion-Clipperton Fracture Zone

[redacted]

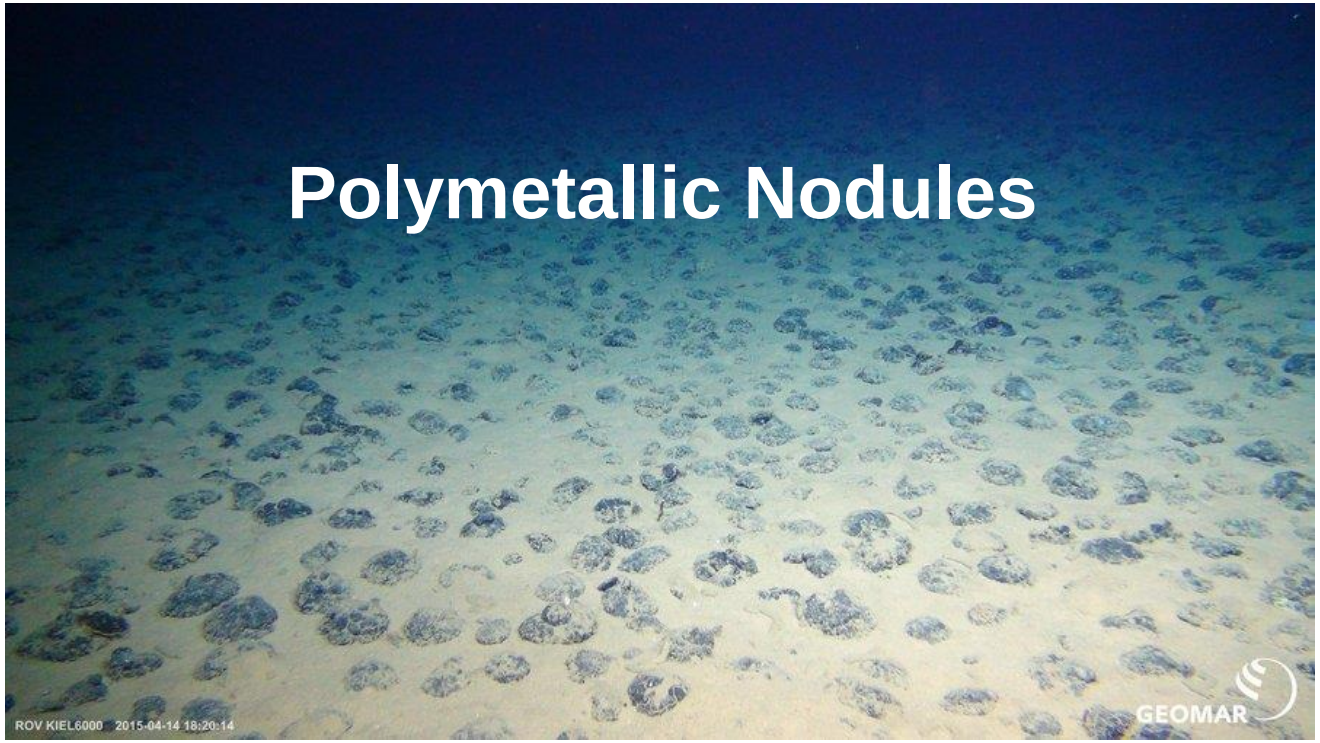
Local Guide · 13 reviews · 278 photos

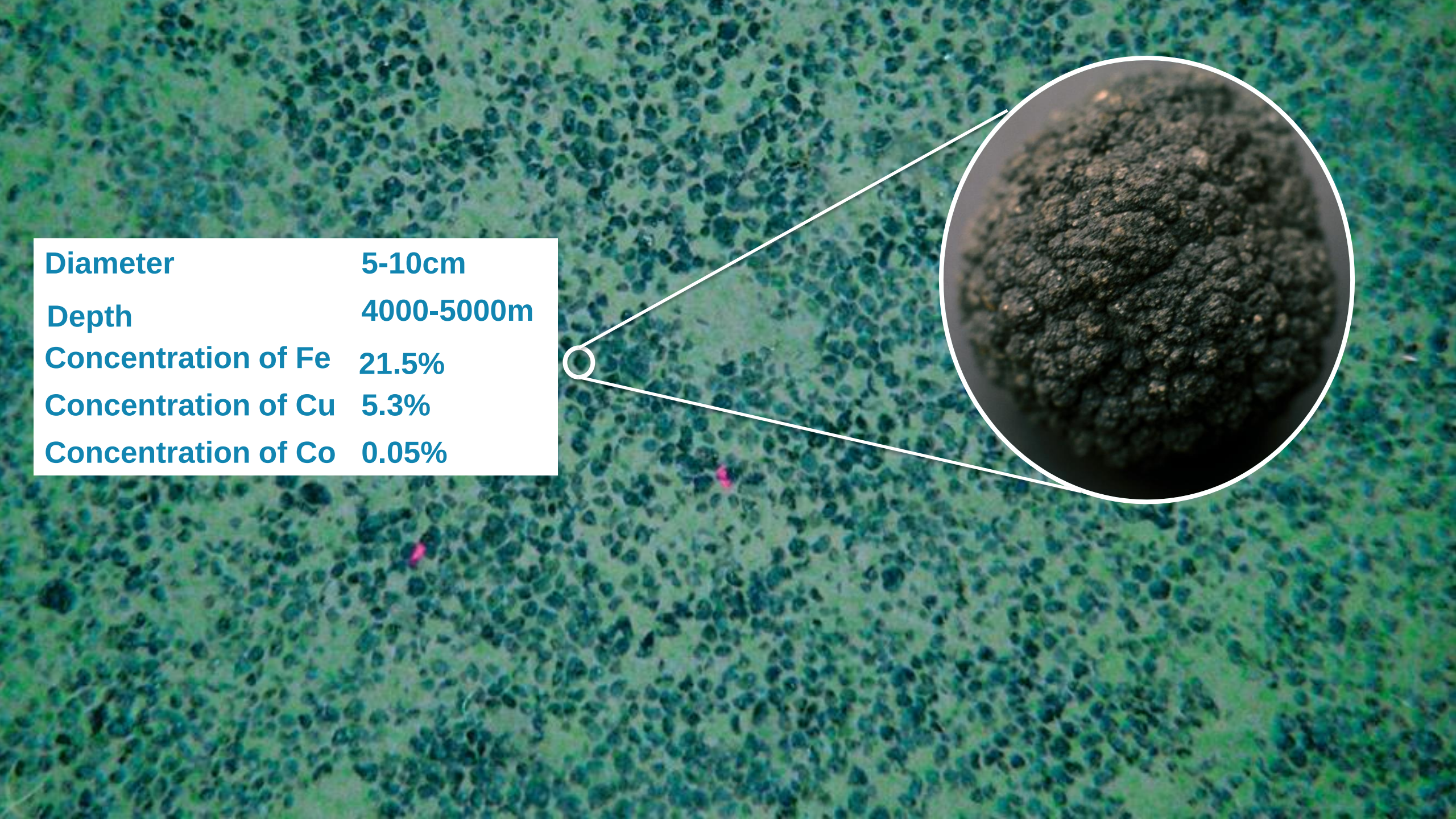
★ a month ago

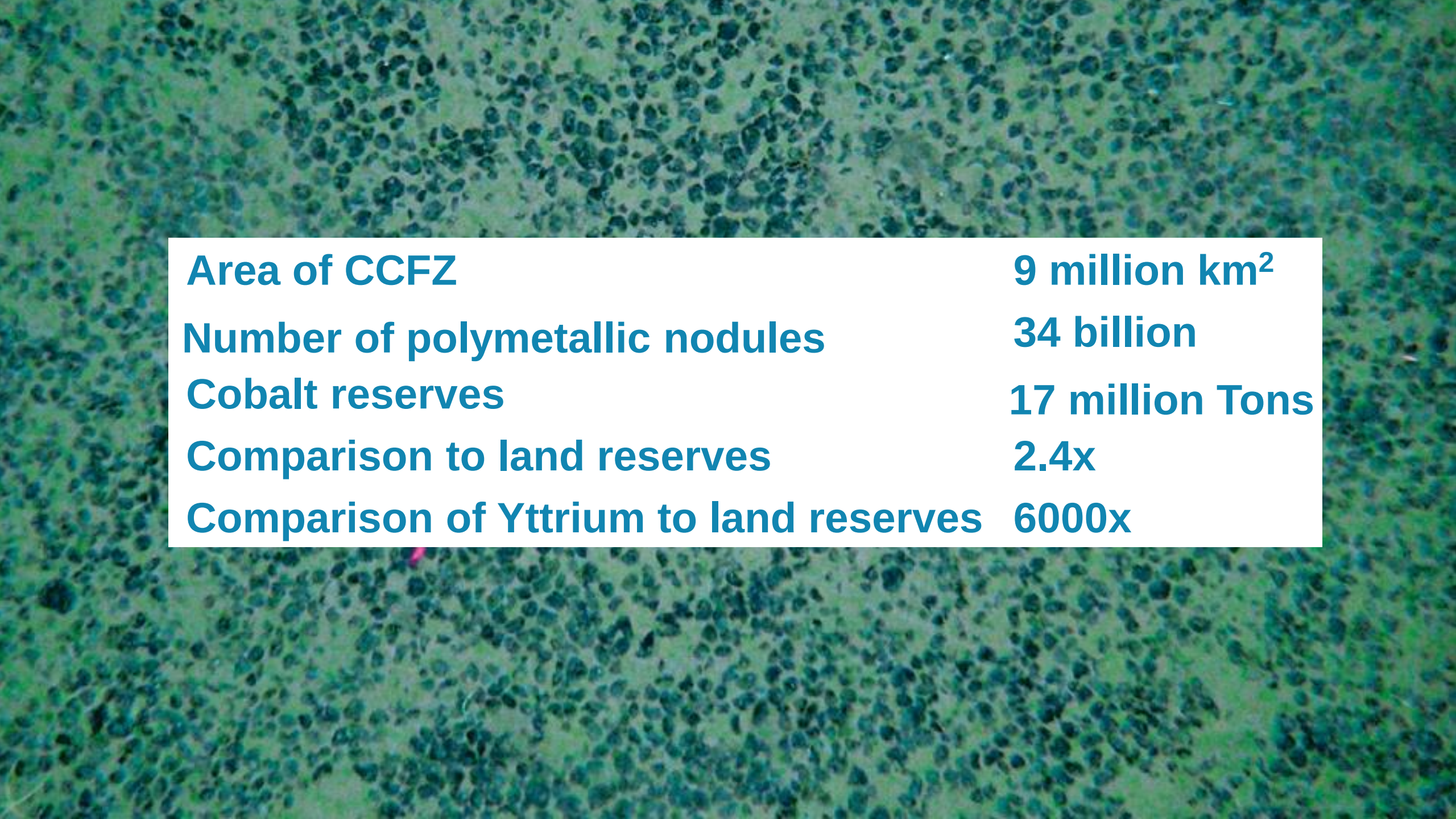
It totally sucks here. There's literally nothing to do. No atmosphere, nothing, zilch.

2 Share

Clarion-Clipperton Fracture Zone




Diameter 5-10cm
Depth 4000-5000m
Concentration of Fe 21.5%
Concentration of Cu 5.3%
Concentration of Co 0.05%



Area of CCFZ	9 million km^2
Number of polymetallic nodules	34 billion
Cobalt reserves	17 million Tons
Comparison to land reserves	2.4x
Comparison of Yttrium to land reserves	6000x

There’s a reason nobody is doing this yet

- Tough technical challenges
  - Less than 10% of ocean has been mapped
  - Near 0 °C
  - High pressure
  - Corrosive
  - Subject to temperature swings

1. Non-intrusive, ecosystem-stabilizing deep sea mining techniques
2. Machinery that can operate underwater for the duration of the mining operation
3. Sensors/imaging techniques that work in harsh environments

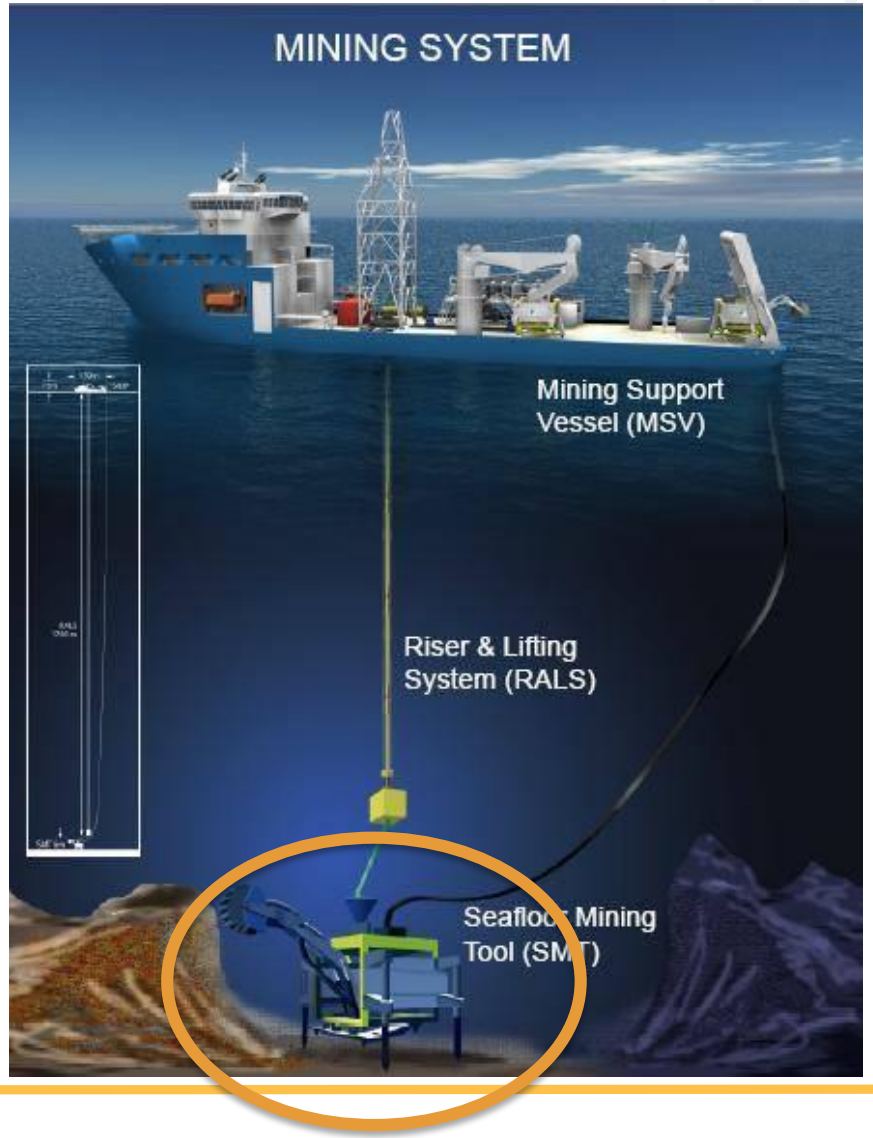
Ecological Design Constraints

- Newly discovered species in the abyssal plains
- Sediment displacement during mining
- Anthropogenic light, noise and vibration can disturb the sea life

PC: Diva Amon and Craig Smith

The Collector is a Crucial Component with Room for Innovation

- Needs to collect enough to be profitable
- Vacuum-based collectors
- Minimal contact between collector and sea floor
- Separation of minerals and waste sediment close to the sea floor
- Waste water discharge near the surface (artificial upwelling)

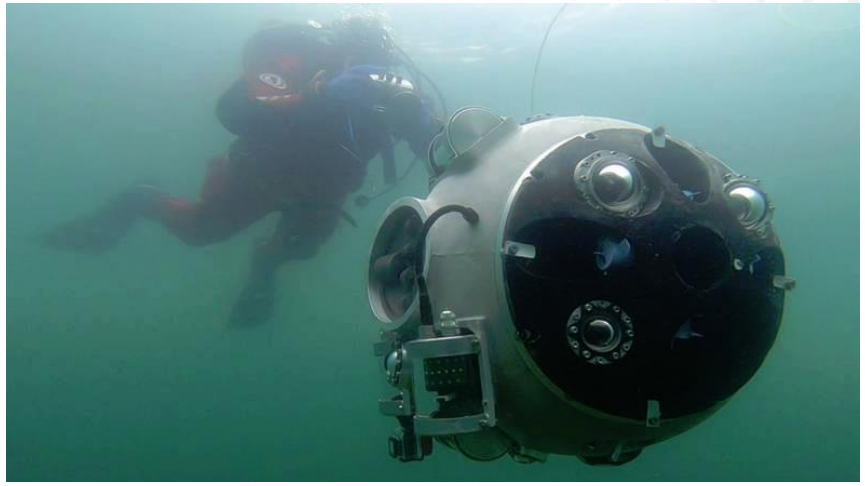


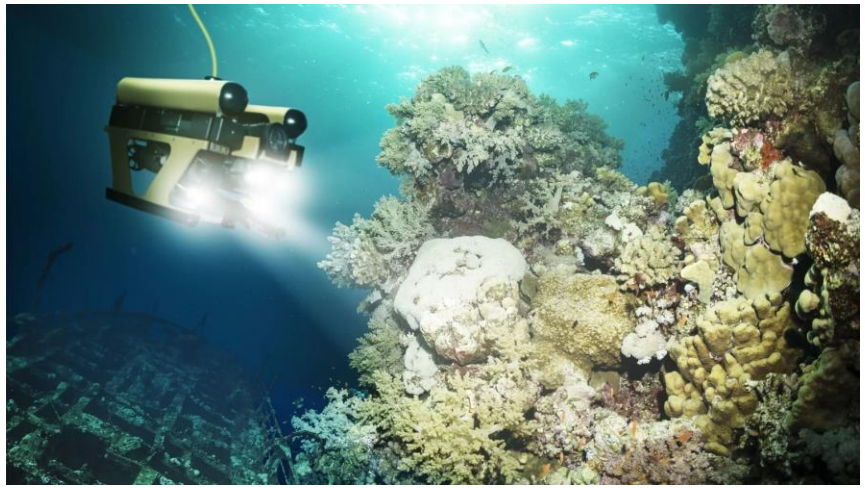
https://eddypump.com/education/subsea-mining-deep-sea-dredging/

Sensors for Deep Sea Mining

- Rechargeable Autonomous Underwater Vehicles or Remotely Operated Vehicles for resource mapping and monitoring

- Modifying existing subsea technologies for identifying surface resources at deeper depths and for longer durations

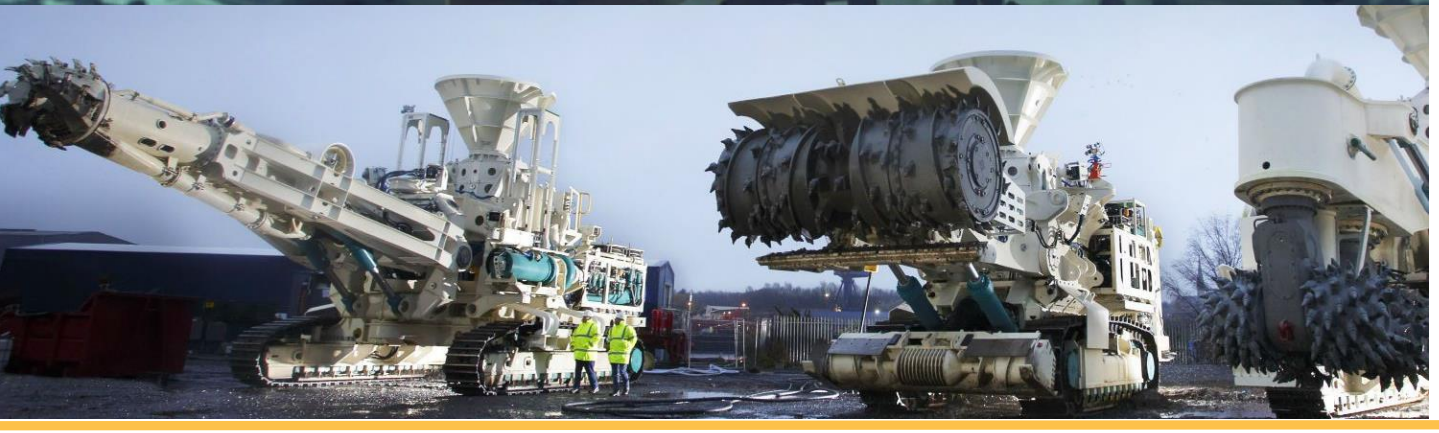




a UX-1 HROV. Photo: EU UNEXMIN Project Shutterstock

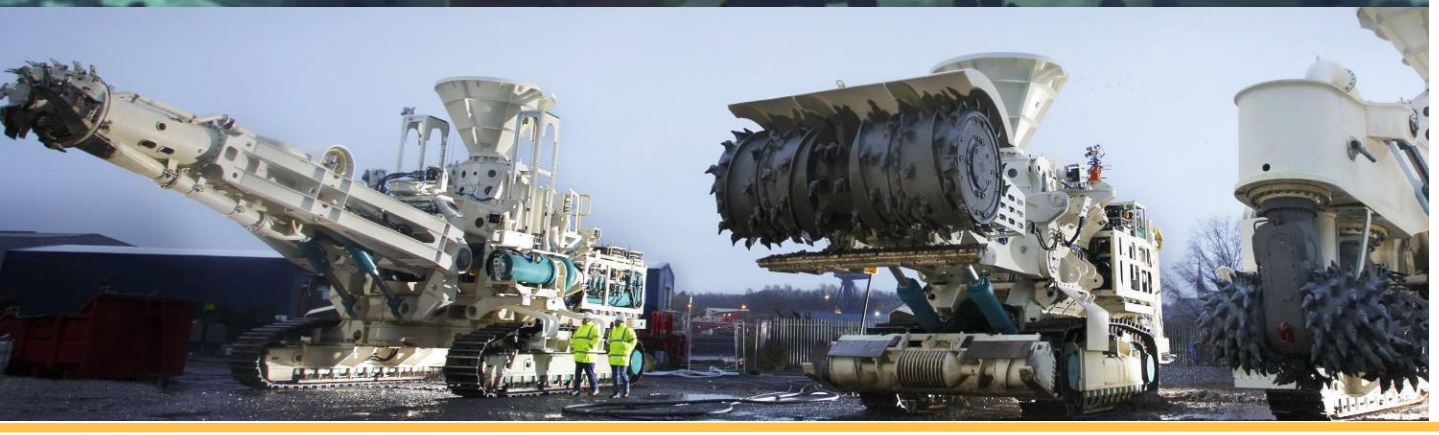
DEME (Belgian)

DeepGreen (Canadian)



Nautilus Minerals (Australian)

https://www.deme-group.com/news/deme-unveils-innovative-nodule-collector-pre-prototype-patania-ii
https://deep.green/
http://www.nautilusminerals.com/irm/content/seafloor-production-tools.aspx?RID=333



Where is the American Design?

https://www.deme-group.com/news/deme-unveils-innovative-nodule-collector-pre-prototype-patania-ii
https://deep.green/
http://www.nautilusminerals.com/irm/content/seafloor-production-tools.aspx?RID=333

In Conclusion…

- Need reliable access to critical mineral to keep up with growth in clean energy technologies and achieve energy and resource independence

- Lots of tech/infrastructure/environmental work needs to be done

- Make U.S. leader in this space

Please get in touch!

- Office Hours – Wednesday 8am Adams Ballroom
- Bring me your ideas:
  - Deep sea mining collector designs
  - Sensors for deep sea mining operations
- Other broad areas of interest
  - Robust supply chains for clean energy technologies
  - Subsurface innovations
  - Digital transformation of energy industries

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