Angling for Amperage
Deep Sea Mining for Critical Minerals

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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

- Domestic Cobalt: 0%
- Imported Cobalt: 100%
- Domestic Nickel: 41%
- Imported Nickel: 59%

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

1000x more Cobalt needed than we can currently recycle!
Clarion-Clipperton Fracture Zone

5 km ↓

Photo: ROV-Team/GEOMAR (CC BY 4.0)

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

Polymetallic Nodules
Diameter: 5-10 cm
Depth: 4000-5000 m
Concentration of Fe: 21.5%
Concentration of Cu: 5.3%
Concentration of Co: 0.05%
<table>
<thead>
<tr>
<th><strong>Area of CCFZ</strong></th>
<th>9 million km²</th>
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</thead>
<tbody>
<tr>
<td><strong>Number of polymetallic nodules</strong></td>
<td>34 billion</td>
</tr>
<tr>
<td><strong>Cobalt reserves</strong></td>
<td>17 million Tons</td>
</tr>
<tr>
<td><strong>Comparison to land reserves</strong></td>
<td>2.4x</td>
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<tr>
<td><strong>Comparison of Yttrium to land reserves</strong></td>
<td>6000x</td>
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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
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
DEME (Belgian)

DeepGreen (Canadian)

Nautilus Minerals (Australian)
Where is the American Design?
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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