Mining the Deep Seabed

A viable approach to meeting the critical needs of the U.S. for secure, responsibly sourced metals for a green energy future

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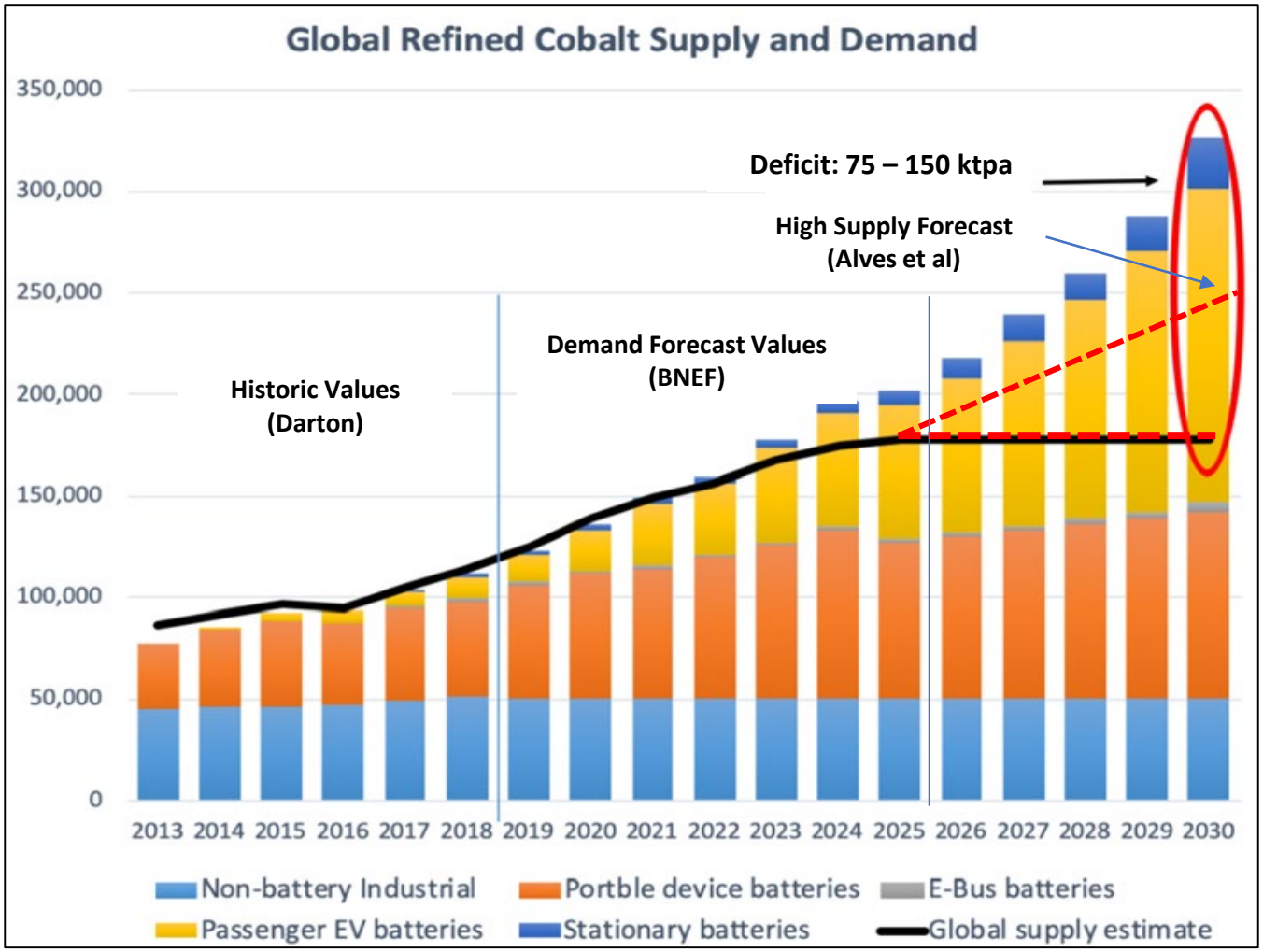
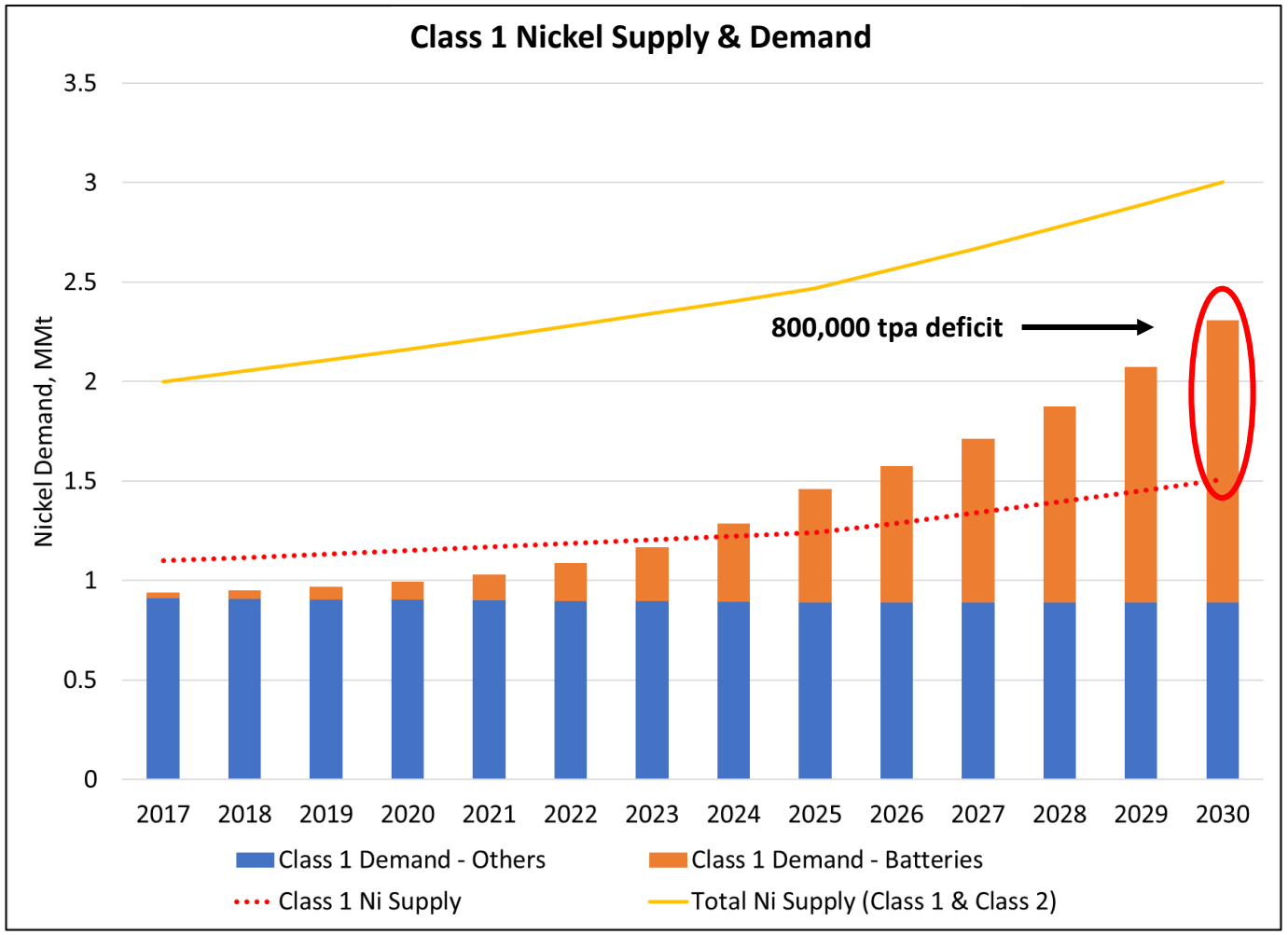
Electric vehicle growth will lead to deepening shortages of metals abundant on the seabed



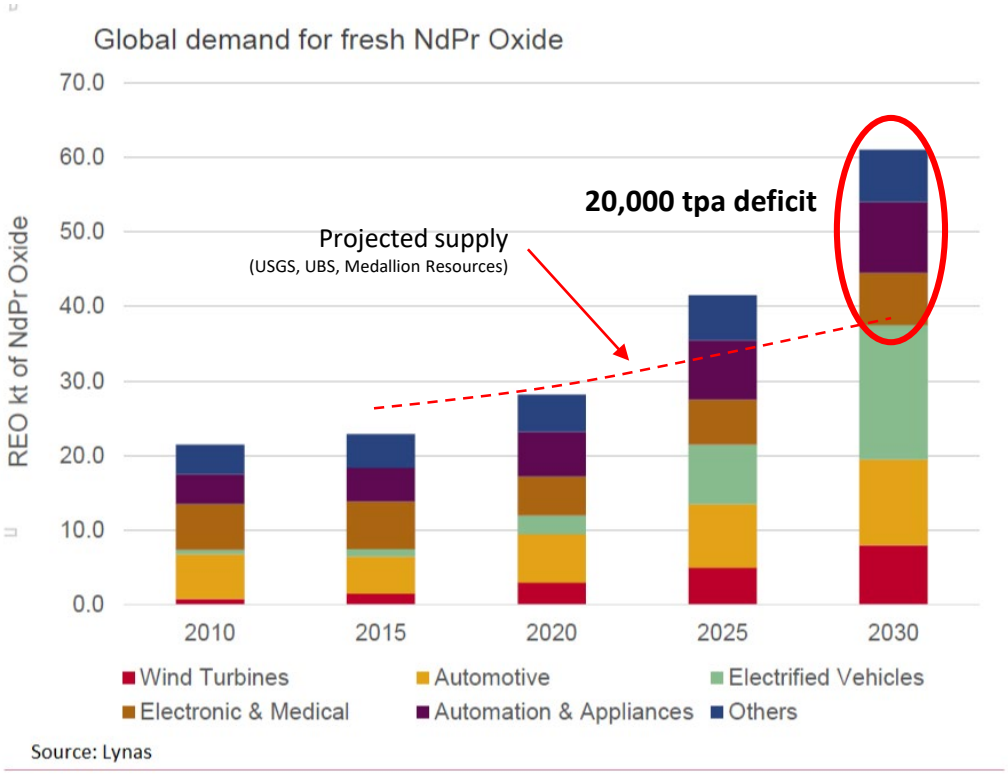
Sources:
John Petersen, 2019 AABC Conference, Ocean Minerals internal analysis
Supply Forecast: Darton Commodities Ltd. Cobalt Market Review 2018-2019 (through 2025)
Supply Forecast: Alves et al, "Cobalt: demand-supply balance in the transition to electric mobility" (2026-2030 incl recycling)
Demand Forecast: Bloomberg News "Cobalt Battery Boom Wavers as Prices Slide in Top User China", June 10, 2018

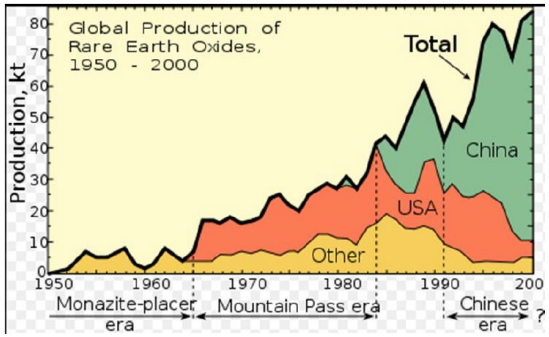
Electric vehicle growth will lead to deepening shortages of key metals for a green economy



Source: Derived from McKinsey & Company (2017) "The future of nickel: a class act", Basic Materials

EV demand will also result in a shortage of rare earths neodymium and praseodymium for electric motors





China has achieved a hegemony on rare earth production and processing

Illegal mining of heavy rare earth elements in China has recently stopped. China's internal demand for magnet metals is soaking up the world supply.

Source: VOANews, Feb. 2, 2016

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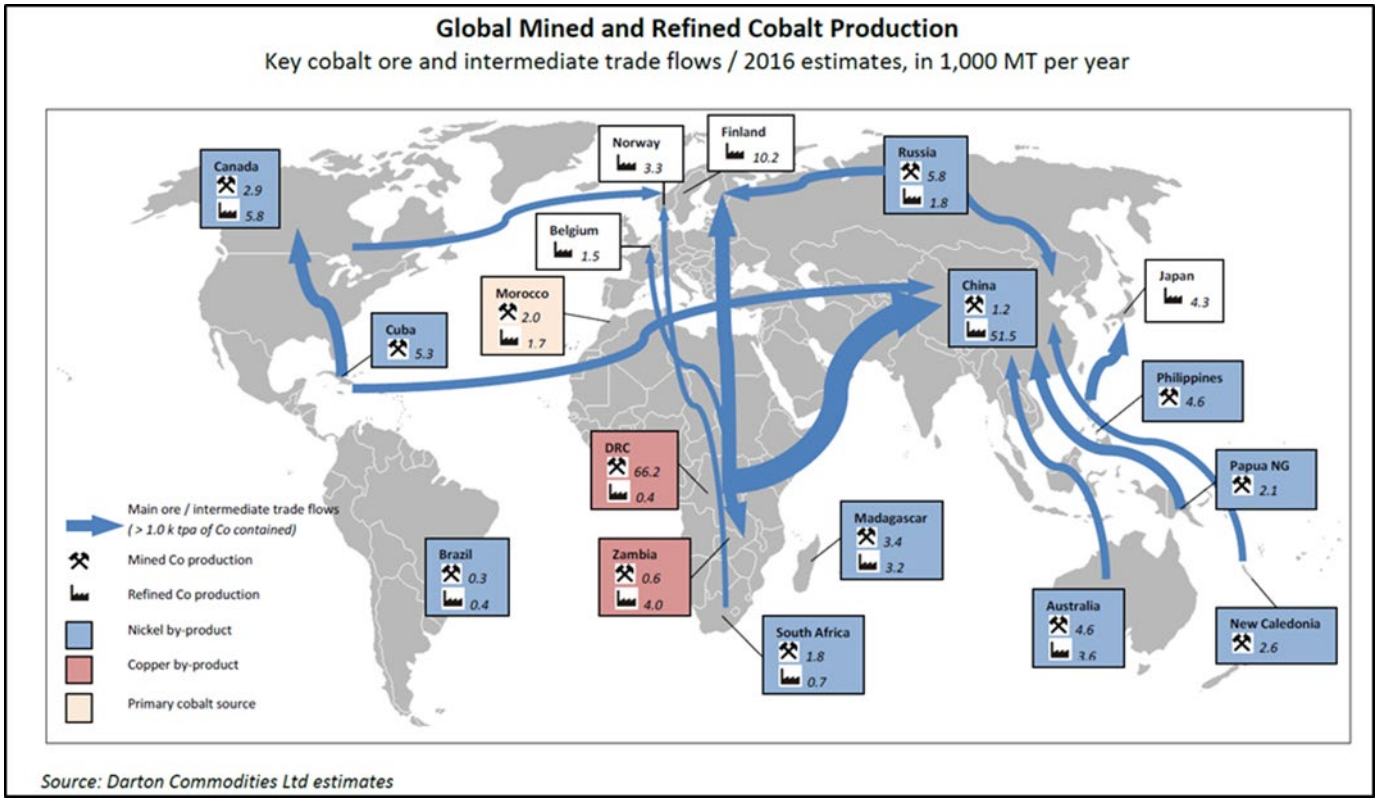
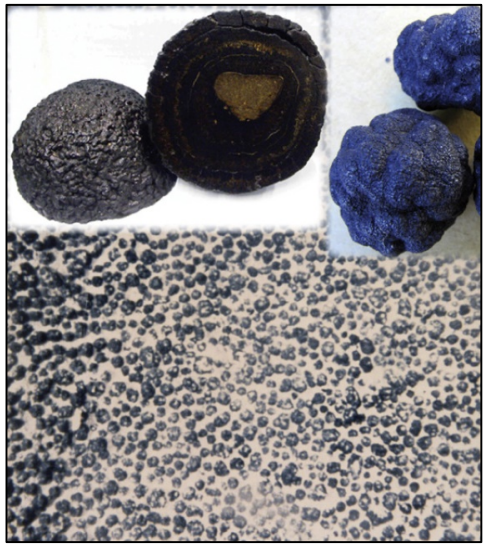
Geopolitics of cobalt



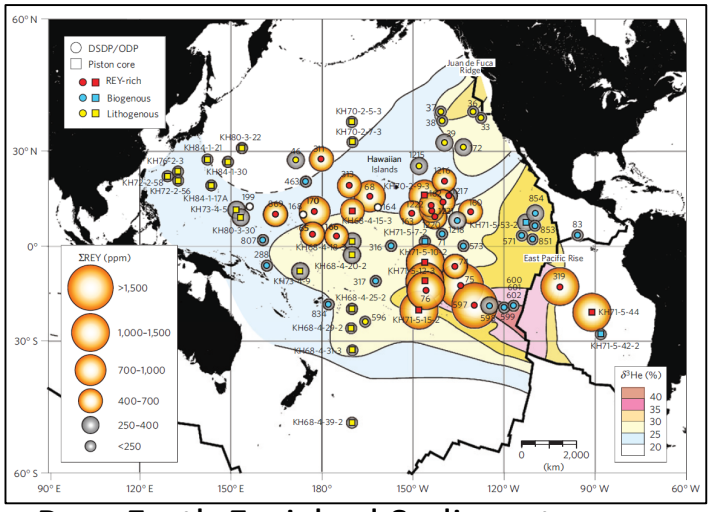
Artisanal mining with child labor in the DRC has been criticized by Amnesty International.

- China dominates the cobalt supply chain for battery grade cobalt: large ownership stake in the main producing country, Democratic Republic of Congo (DRC), and 80% of the world's refining capacity.

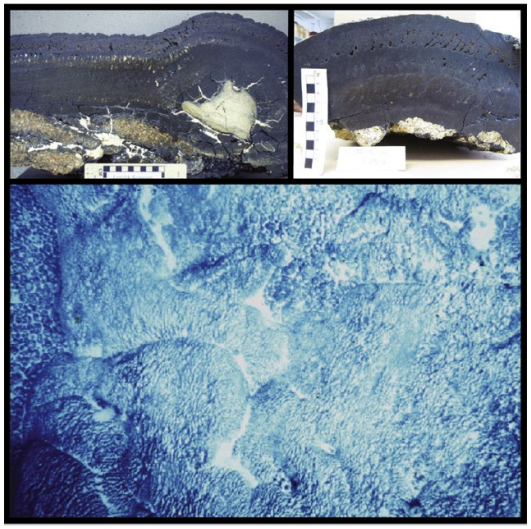
Primary types of deep seabed mineral resources



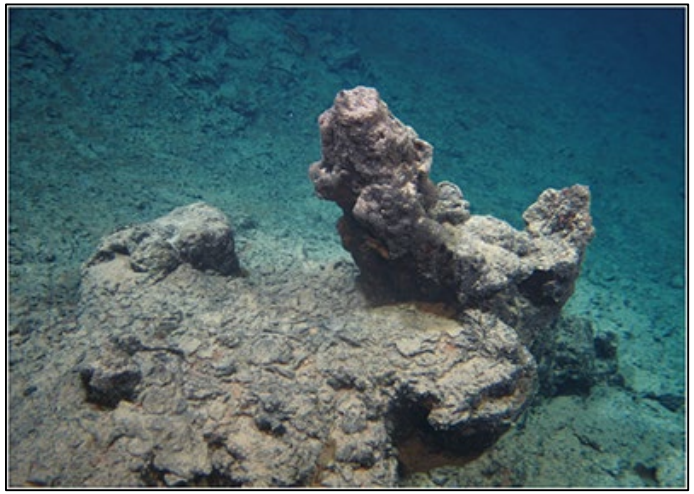
Fe-Mn Nodules on Abyssal Plains
4000 – 6000 m (Ni, Cu, Co, Mn)
[from Hein, et al, Ore Geol. Rev. 51, 1–14, 2013]



Rare Earth Enriched Sediment
Pelagic clays > 4000 m (REEs + Sc)
[from Kato, nat. geos. 3 July 11]



Fe-Mn Crusts on Seamounts
800 – 2500 m (Co, Ni, Mn)
[from Hein, et al, Ore Geol. Rev. 51, 1–14, 2013]



Seafloor Massive Sulfides from hydrothermal vents on Back Arc Basins 1500 – 2500 m (Cu, Ag, Au, Zn)
[from: German Federal Institute for Geosciences and Natural Resources (BGR)]

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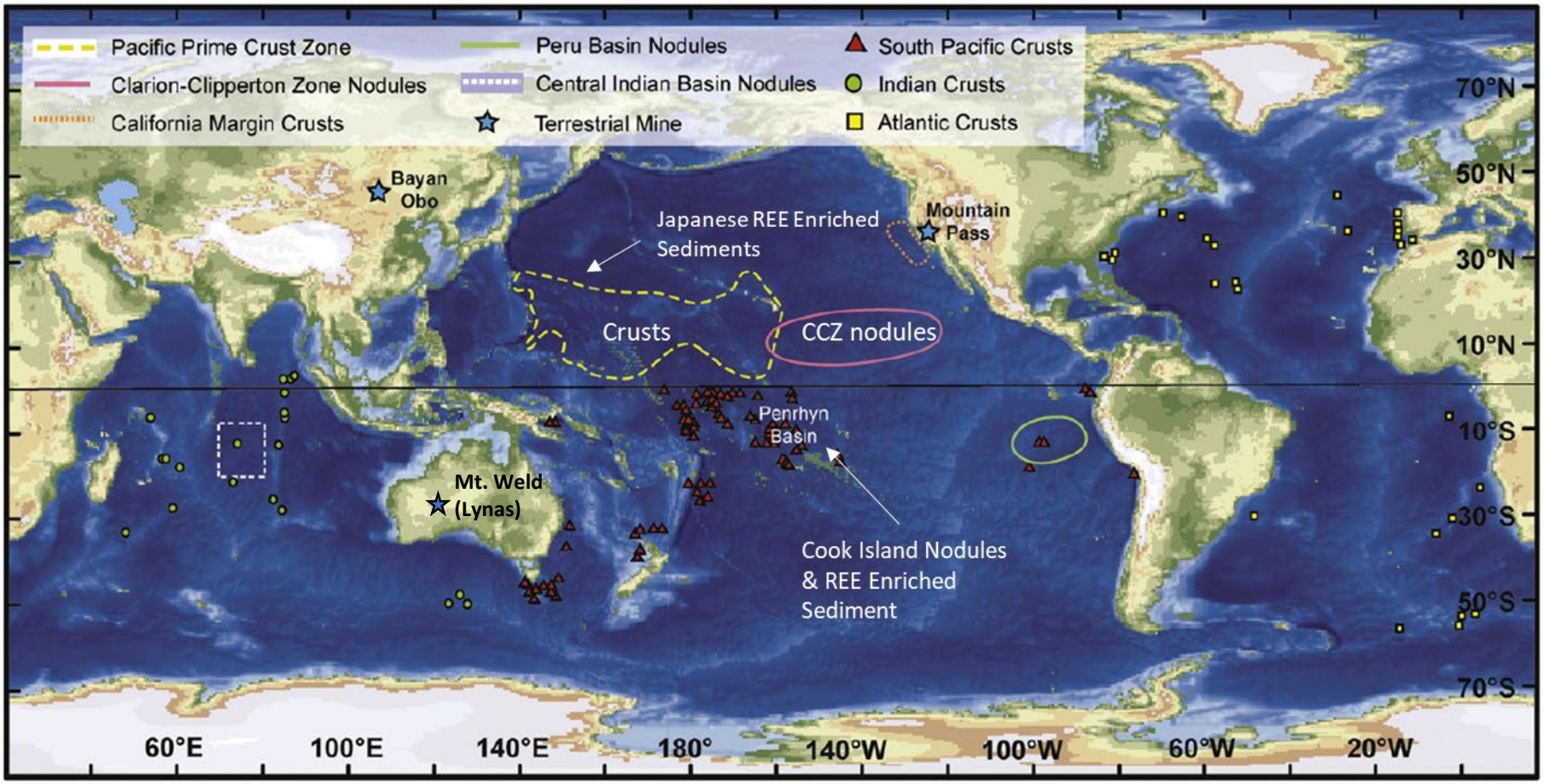
Locations of known seabed mineral resources



Source: Hein et al, 2013

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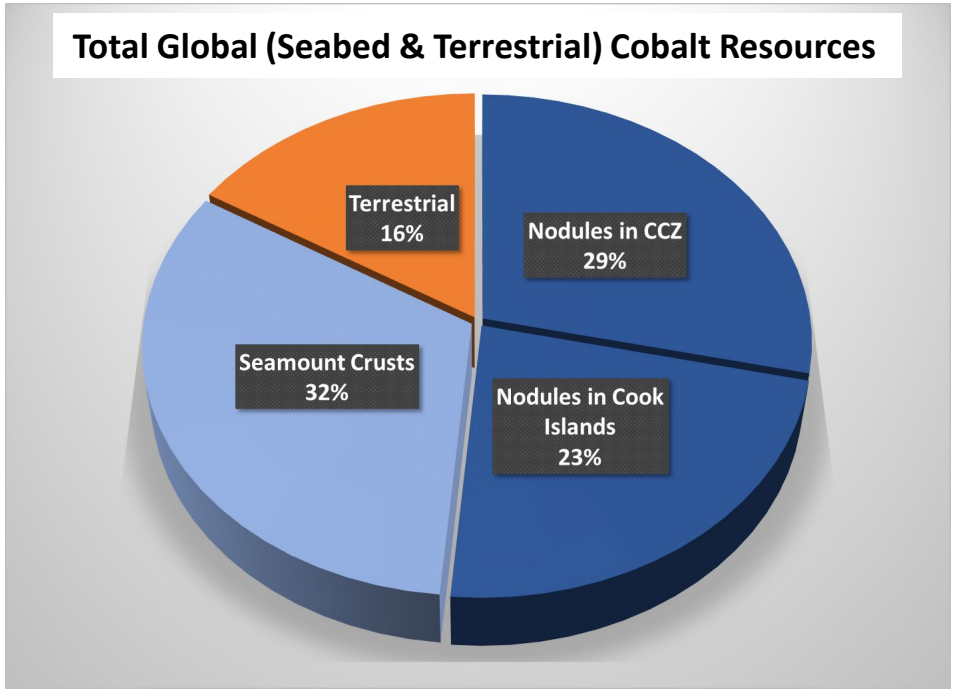
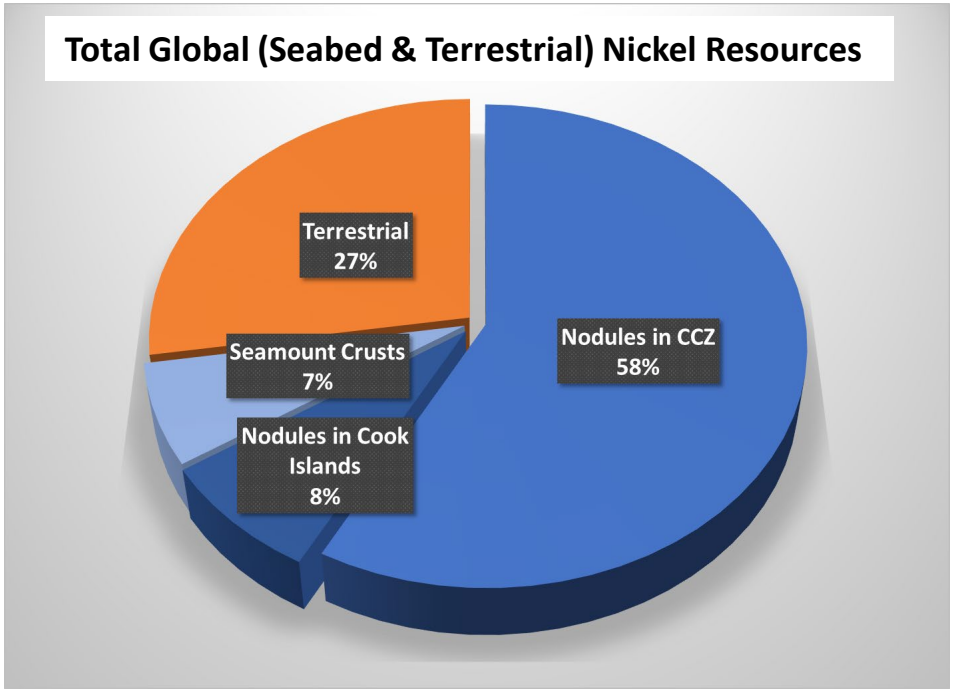
Seabed mineral deposits are many times larger than land-based resources

- ***Pacific seabed*** nodules and crusts contains 4-5 times the nickel and cobalt known on land





Nodules (and crusts), unlike most terrestrial deposits, lie exposed on the seafloor… no overburden, and the deposits are homogeneous over many square kilometers of the seafloor.

Sources:

- USGS National Minerals Information Center Commodity, Summaries for Cobalt and Nickel (Terrestrial Resource)
- James R. Hein, Francesca Spinardi, Nobuyuki Okamoto, Kira Mizell, Darryl Thorburn , Akuila Tawake, 2015, "Critical metals in manganese nodules from the Cook Islands EEZ, abundances and distributions", *Ore Geol. Rev.* 68, 97-116
- Hein, J.R., Mizell, K., Koschinsky, A., Conrad, T.A., 2013, "Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: comparison with land-based resources". *Ore Geol. Rev*. 51, 1–14.

1970s mining consortia established feasibility of mining and processing of nodules

OMA Consortium

Deepsea Ventures, U.S. Steel, Sun Oil & Union Minière

Collected 500 MT of nodules with an airlift riser and hydraulic collector.

OMCO Consortium

Lockheed, Amoco, Billiton & Boskalis

Tested self-propelled collector with mechanical pick-up system.

OMI Consortium

Inco, DOMCO, Preussag, Metallgesellschaft AG & SEDCO

Collected 800 MT of nodules with airlift riser and pump systems.

KCON Consortium

Kennecott, Mitsubishi, Noranda, RTZ, Goldfields & BP Minerals

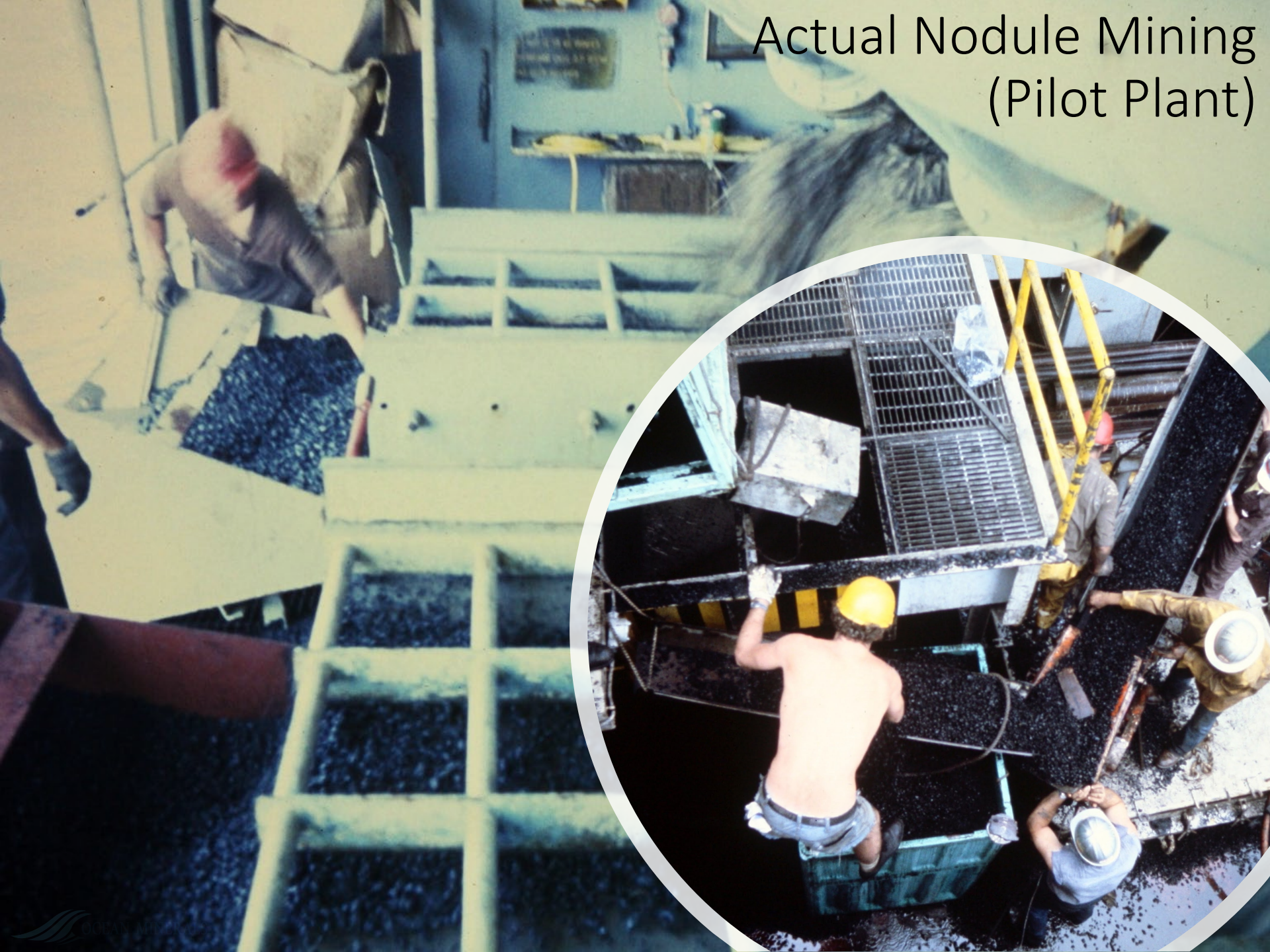
Tested hydraulic towed collector and developed enhanced airlift model.

Pilot test of novel low-temperature Cuprion hydrometallurgical process.

Four international consortia spent over USD $1 Billion (2019 $) to prove the viability of nodule mining and processing, concluding it was

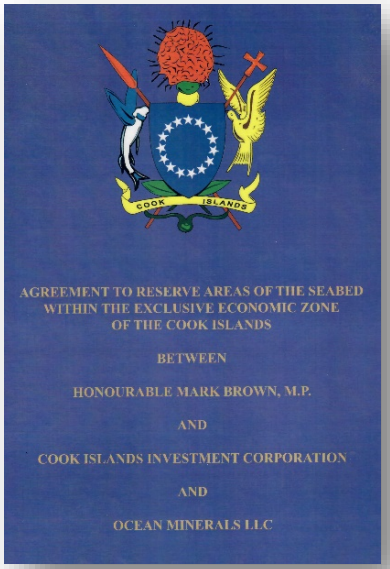
- **Technically feasible, and**
- **Cost competitive with laterites (for Ni)**

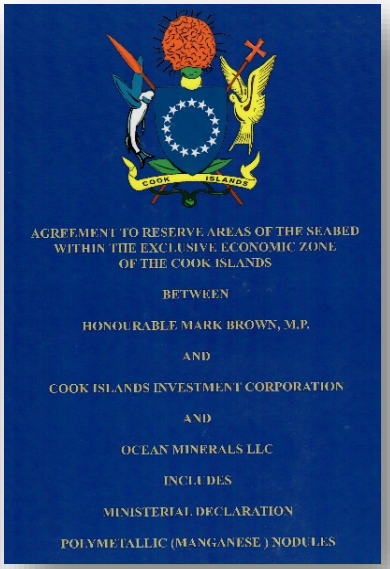
Actual Nodule Mining (Pilot Plant)

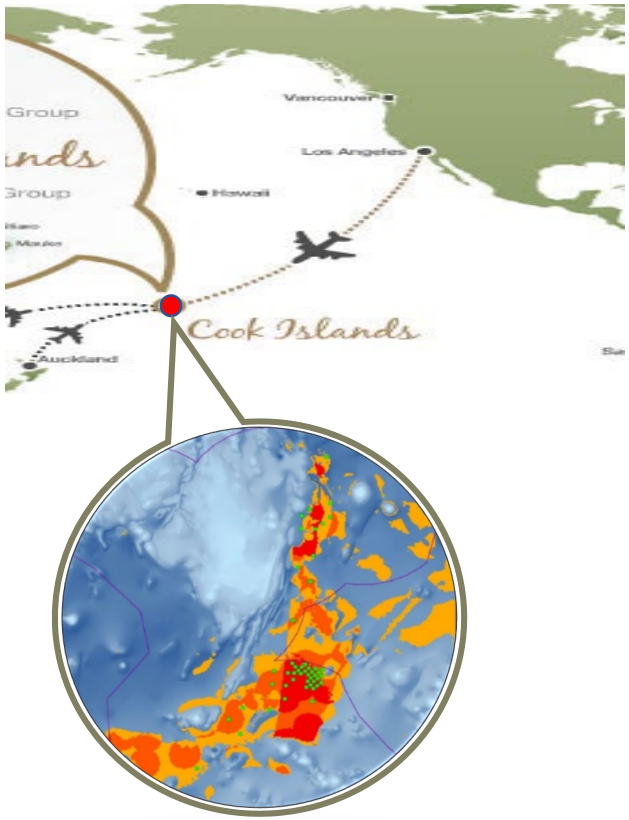


OML's REE and Nodule Projects in the Cook Islands

- ***OML has exclusive rights to apply for rare earth enriched sediment exploration licenses in a 12,000 km² area.***
- ***OML has exclusive rights to apply for cobalt-rich nodule exploration licenses in a 24,000 km² area.***





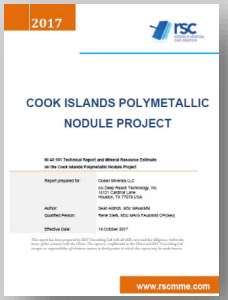


The Cook Islands is a Sovereign Commonwealth Nation with a commitment to see seabed mining succeed.

Nodules contain cobalt, nickel, and manganese

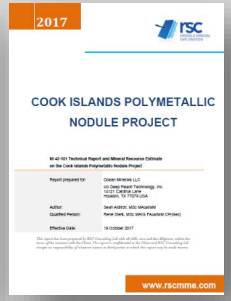
- OML has a large cobalt resource identified within the Cook Islands Exclusive Economic Zone.
- This is a primary cobalt resource: 0.5% cobalt compared to <0.1% in many nickel based terrestrial deposits, and <0.2% in CCZ nodules.
- Large exploration target of a further 1.5MM MT of cobalt is present in existing resource area.

Polymetallic Nodules



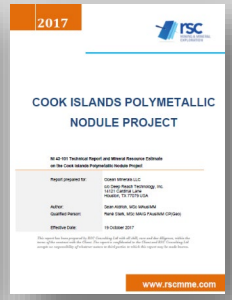
200
Million Dry Tonnes

Cobalt Grade



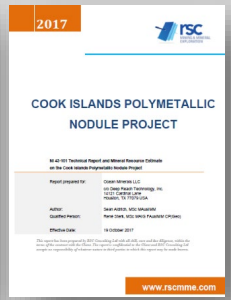
0.5%
(Ni, Cu & Mn Byproducts)

Average Abundance



28
Kilograms (wet)/ m^2

Estimated Mine Life



40+
At 12,000 MT / Yr of Cobalt.

OML's NI 43-101 Resource report lists the following metal tonnages within the region.

Cobalt
1,000,000 mt contained metal

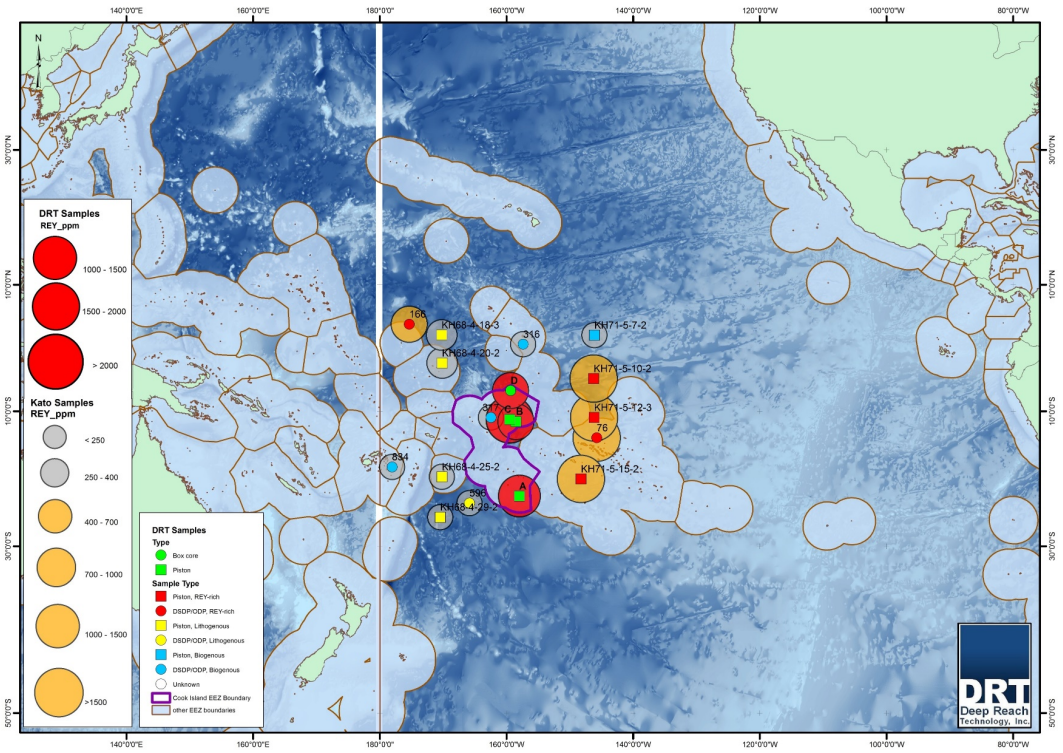
Nickel
470,000 mt contained metal

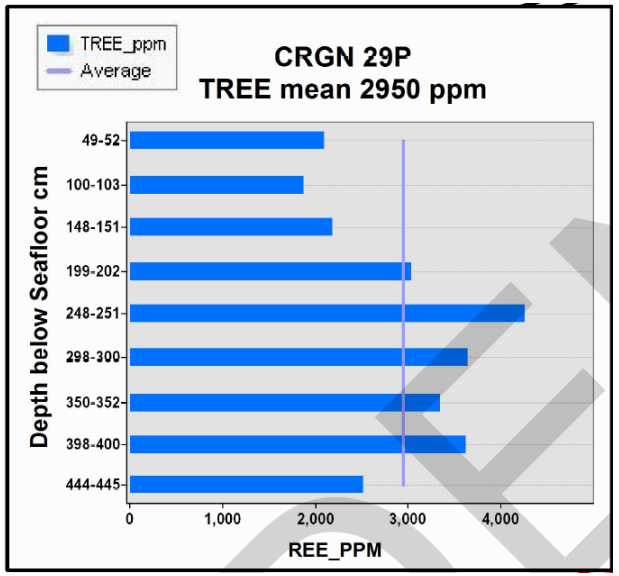
Manganese
31,000,000 mt contained metal

Copper
260,000 mt contained metal

Cook Islands also has REE Enriched Seabed Sediment

- 2014: US Department of Defense / Army Research Lab awarded research agreement to Deep Reach Technology to investigate seabed recovery of REEs, (2 YR/$2M study) which led to the discovery of a potential commercially recoverable deposit in the Cook Islands.
- The Cook Islands deposit is particularly high in the percentage of valuable heavy rare earth elements (HREEs).
- Similar deposits have been found in the Japanese EEZ and may exist in the US EEZ!





- Upper 4-m of sediment REE content averages 3000 ppm

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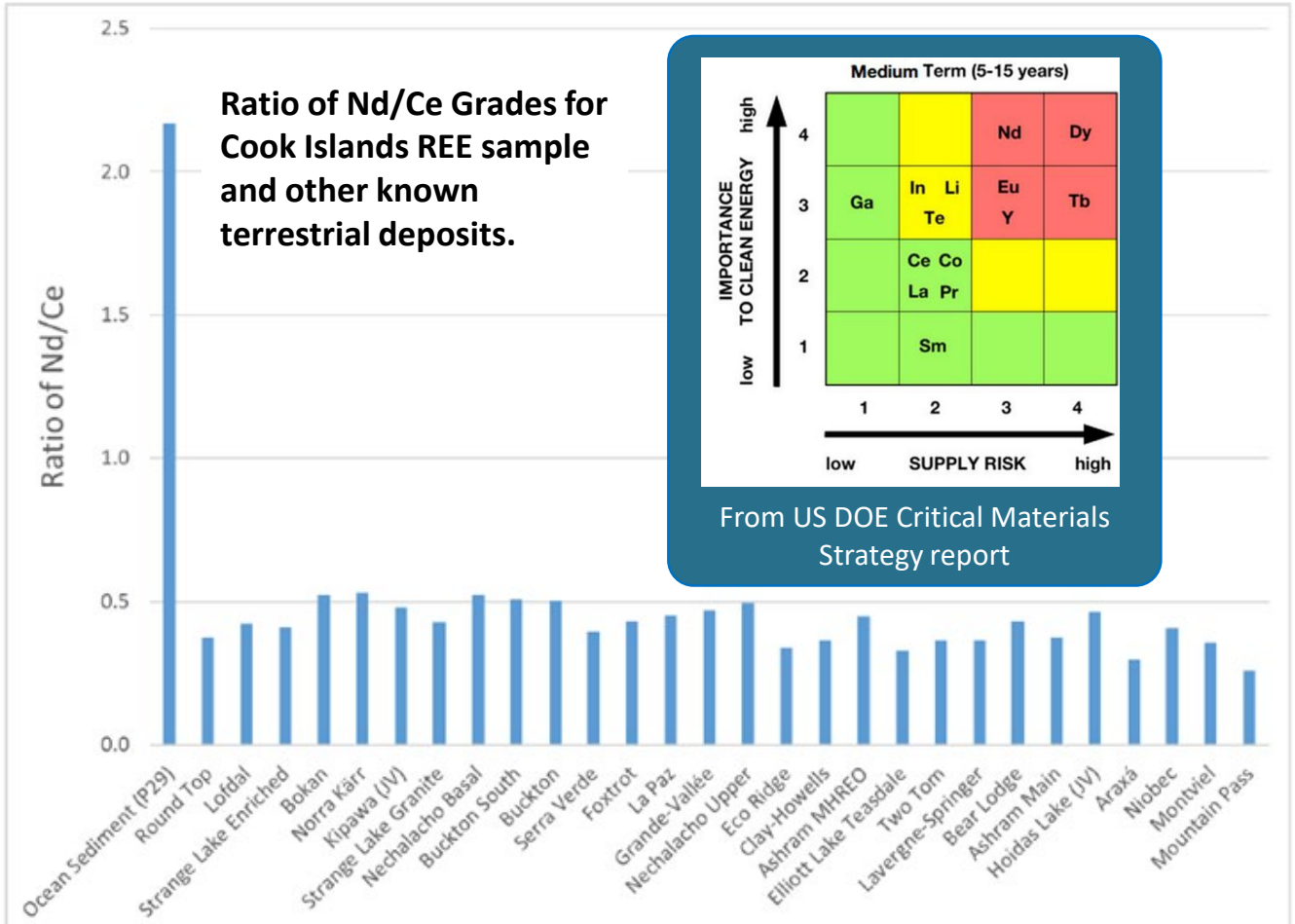
Seabed REE Enriched Sediments in the Cook Islands are uniquely rich in critical elements



From US DOE Critical Materials Strategy report

The REE Enriched Sediments in the Cook Islands are high in the percentage of critical magnet metals: NdPr and DyTb.

Product	Estimated Production (tpy)
La2O3	2,660
CeO2	1,317
Pr6O11	524
Nd2O3	2,173
Sm2O3	536
Eu2O3	106
Gd2O3	481
Tb4O7	77
Dy2O3	548
Ho2O3	113
Er2O3	288
Tm2O3	46
Yb2O3	220
Lu2O3	37
Y2O3	3,589
Sc2O3	212
Total	**12,927**

Shaded cells are “Critical Rare Earth Elements” per US DOE!

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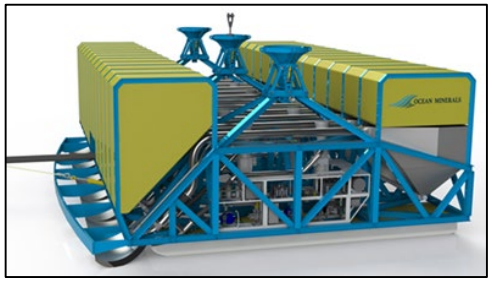
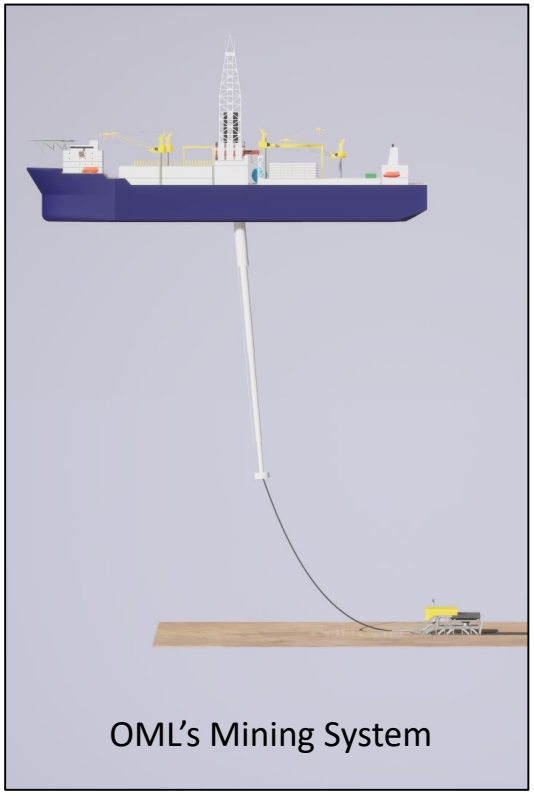
OML's Cook Island Nodule Project to produce 12,000 MT per year of cobalt

- Uses **field-proven technology**
- Converts **existing ore carriers** for mining and transportation
- Implements **improvements pioneered by deep water oil & gas** industry
- Provides **scalable** & modular production volume growth with additional vessels
- **Uncomplicated mining** process aided by
  - nodules lying uncovered on the seafloor
  - Homogeneous nature of the ore body
- **Production** projected to commence in **2026**

OML's Nodule Collector



Underwater Diamond Dredge



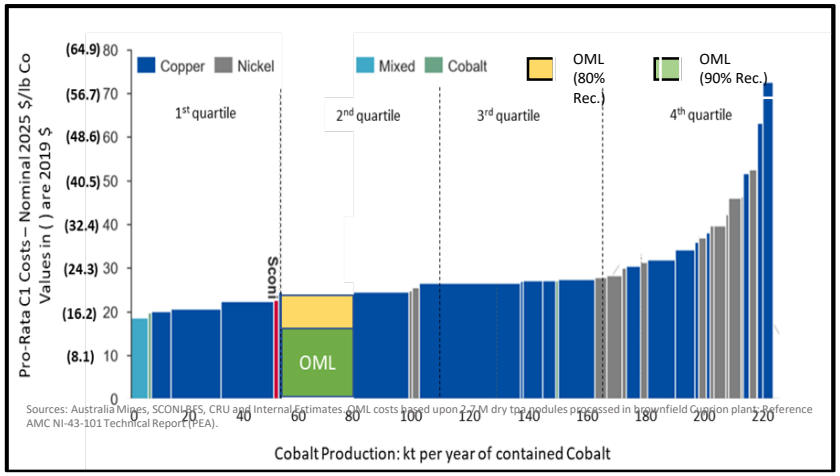
OML's Mining System

Nodule mining and processing C1 costs

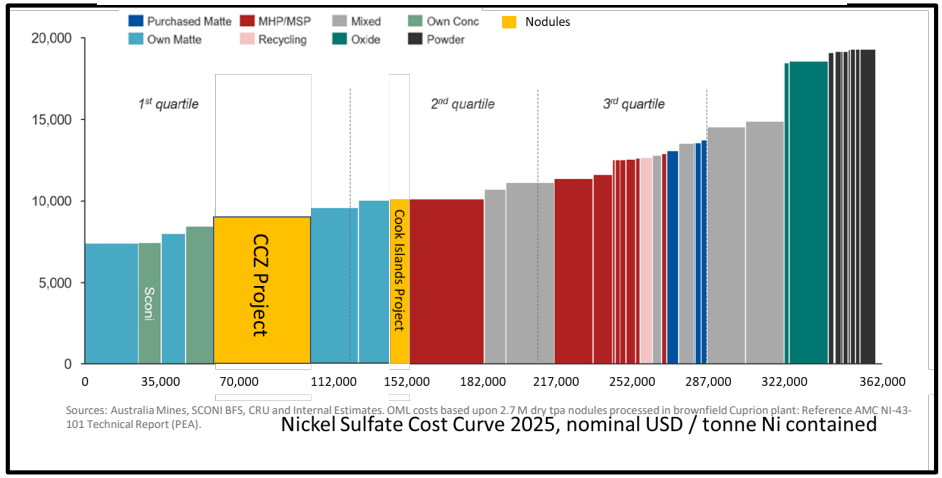
- Battery grade cobalt sulfate from nodule been estimated to be in the 2nd quartile of costs when compared with terrestrial copper and nickel-based cobalt.

- Battery grade nickel sulfate costs from nodules have been estimated to be in the 1st and 2nd quartile of costs when compared with terrestrial sources.

Global Cobalt Sulfate Production Cost Curve



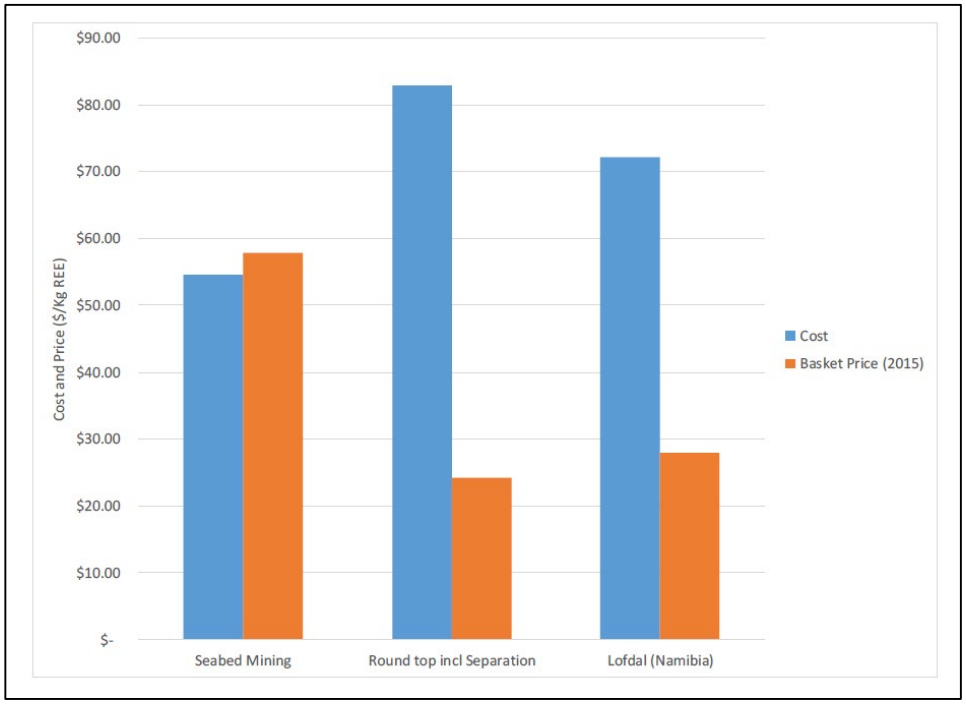
Global Nickel Sulfate Production Cost Curve

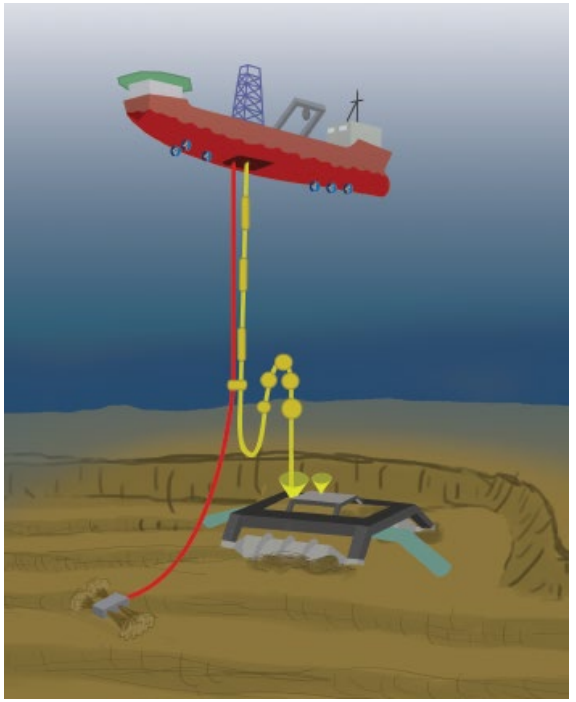


Costs of producing battery grade cobalt and nickel from nodules could be lower than most land-based options.

Cost of recovering REEs from sediment is competitive

Seabed Sediment REE Production Cost / Revenues versus Example Projects





- Seabed Sediment REE costs for mining and extraction have been estimated to be competitive with new terrestrial projects
- The commodity basket is weighted toward critical and valuable rare earth elements, which supports development.

Roadmap to commercialization on nodule project

OML Nodule Mining Project Development

Key Milestones reflecting Associated Cummulative Costs

	OML's Cummulative	2018				2019				2020				2021				2022				2023				2024				2025				2026			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Issue Resource Report - NI 43-101	$1,000,000	■																																			
Publish Peliminary Economic Assessment	$3,000,000							■																													
Award of Exploration Licenses	$4,000,000									■																											
Complete Expedition #1 (Bulk Nodules)	$10,000,000										■																										
Complete Metallurgical Testing of Nodules	$15,000,000												■																								
Publish initial Pre-Feasibility Report (PFS)	$16,000,000												■																								
Publish Updated Pre-Feasibility Report	$26,000,000														■																						
Offtake Agreement Finalised	$28,000,000																		■																		
Submit Environmental Impact Assessment (EIA)	$30,000,000																				■																
Publish Detailed Feasibility Study (DFS)	$34,000,000																						■														
Approval of EIA & Award of Mininig License	$35,000,000																								■												
Project Sanction																										■										
Start of Production																																					■

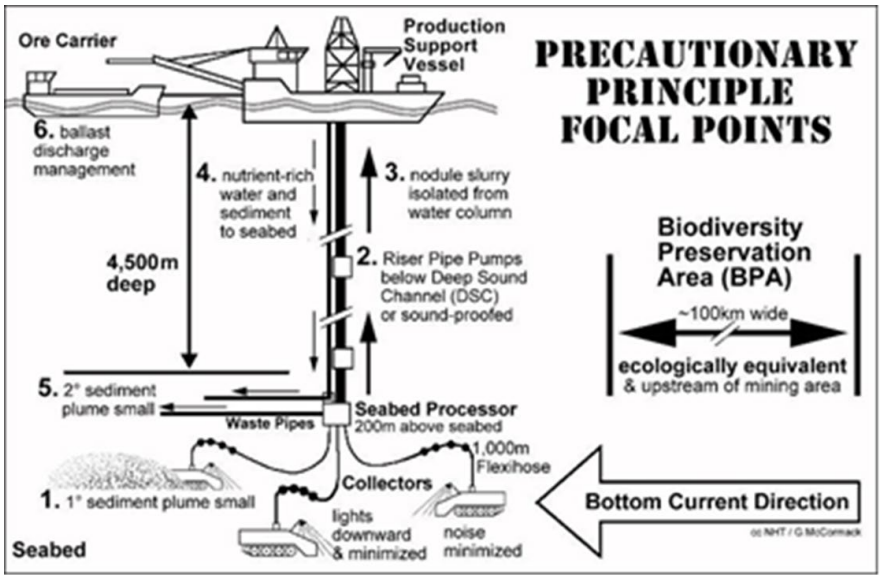
Project Expense Assumptions

- Mining system development and pilot testing costs carried by strategic partner.
- Processing system development and pilot testing costs carried by strategic partner.

Production can commence within 7 years provided early stage support and funding is forthcoming.

OML's commitment to responsible seabed mining

- Employ Precautionary Approach in order to ensure minimal harm and impact to the environment.
- Employ adaptive management.
- Apply best available technology.
- Ensure local communities and stakeholders benefit directly.
- Respect the concerns and cultural values of local communities.
- Implement transparency and frequent communications regarding environmental issues.
- Leverage work by others in terms of understanding the environmental stressors and necessary safeguards.
- Design, engineer, and plan for long term, low impact operations.



Source: McCormack, Gerald (2016) "The Environment and the Cook Islands Seabed Minerals - an introduction", Cook Islands Natural Heritage Trust

The project's goal is to economically produce large quantities of Technology Metals in an ethical manner with minimal environmental impacts.

Significant environmental work has been done

- **1975** – Deep Ocean Mining Environmental Study (DOMES): five-year study report published in 1981; formed the basis for NOAA's Deep Seabed Mining Final Programmatic EIS (198x)
- **Late 1970s through the 1990s** – U.S./Russia Benthic Impact Experiment (BIE, BIE-II) followed by a series of other experiments focused on recording the impacts of seabed sediment disturbance and re-deposition (plume testing) resulting from mining
- **1989** – very large DISCOL seafloor disturbance project conducted by German researchers in Peru Basin and revisited multiple times for post-impact studies (JPI Oceans & MIDAS revisited in 2015)
- **2000s** – Kaplan Project (2002 – 2007), focused on biology
- **2013 and 2015** – Abyssline Project cruises, focus on biology
- **2015** – independent EcoResponse (GEOMAR) environmental cruise
  - Studied biodiversity, geology, geochemistry of settings and genetic connectivity between distant deep-sea populations
  - Compared fauna from seamounts with fauna living attached to the nodules
- **Current ongoing work** –
  - All exploration contract holders in CCZ are conducting environmental baseline cruises
  - Preservation Reference Zones (PRZs) mandated by ISA
  - 9, 400x400km "Areas of Particular Environmental Interest" (APEIs) are set aside in the CCZ for protection

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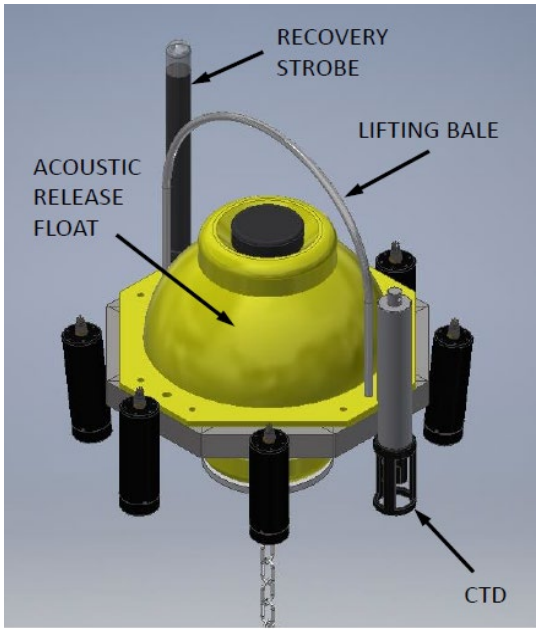
OML work program prior to receiving Exploration Licenses

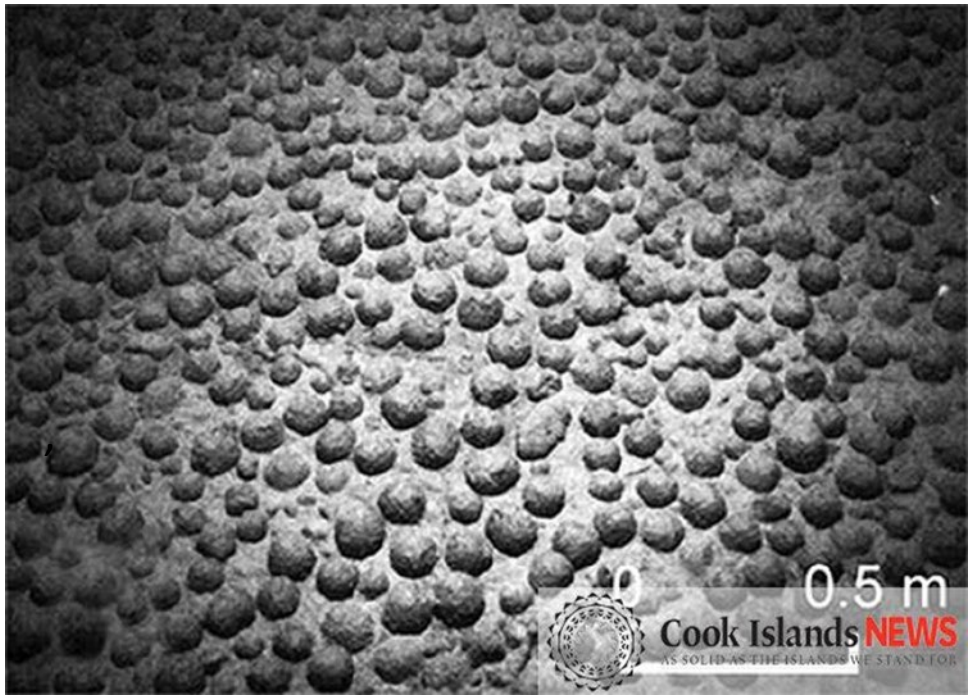
- Focus on low cost, high impact, and locally based methods of initiating the environmental baseline data collection
- Pelagic Observer System (PelagOS) – OML is developing low cost, tablet-based tool to be deployed on variety of local vessels in the Cook Islands to begin the collection of data (Initiated Q1 2019)
  - Birds, mammals, turtles, fish, other vessels, trash
  - Associated geolocation data
  - Associated conditions (sea state, swell conditions, wind, cloud, rain)
  - All local “observers”, trained by OML
- Environmental Scoping Study (initiated Q2 2019)
  - Identify potential environmental stressors
  - Propose methods to measure and assess
  - Coordinate with stakeholders for consensus building
  - Forms framework from which to build environmental program

PelagOS



OML summary

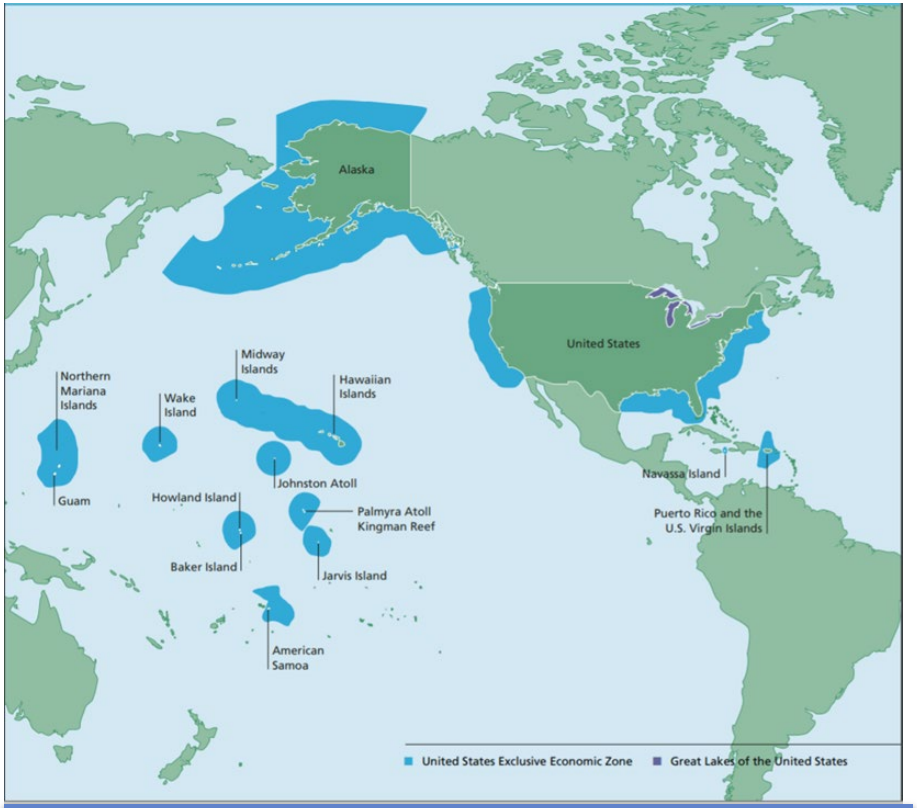
- The seabed Ni and Co potential is many times larger than known land-based resources.
- Seabed resources are available in favorable, non-corrupt jurisdictions.
- Costs to produce battery metals from seabed nodules are competitive with costs of new sources (e.g., nickel laterites).
- The production of Rare Earth Elements from the seabed has real and scalable potential.
- We believe the environmental and social consequences of seabed mining are manageable.



Cobalt-rich nodules in the Cook Islands' Exclusive Economic Zone (EEZ)

Current status & way forward

- OML provides the US with a direct path to strategic resources in CI EEZ.
- EU, China, Japan, Korea, and Russian governments actively support underwater mining development.
- OML requires early stage support to develop the project.
- Prompt action is needed to ensure certainty and security of supply.



OML is the ONLY US Entity with access to these valuable and strategic deep seabed resources. All other key nations are pursuing deep ocean resources.

Contact us

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