The background of the slide is a photograph of an underwater mining operation. It shows a large, dark, mineral-rich rock formation being processed by a complex piece of machinery. The machinery includes a yellow cylindrical component and various pipes and structural elements. The scene is illuminated by artificial lights, creating a blue and green color palette. The text is overlaid on the top left portion of the image.

Marine Minerals

U.S. Geological Survey and Department of the Interior Efforts

David B. Diamond
Deputy Associate Director for
Energy and Minerals
U.S. Geological Survey

Renewable Natural
Resources Foundation
May 29, 2019

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- US Geological Survey (USGS)
 - James Hein, Amy Gartman, Guy Gefelnbaum – Pacific Coastal and Marine Science Center
 - John Haines – Program Coordinator, Coastal/Marine Hazards and Resources
- Bureau of Ocean Energy Management (BOEM)
 - Jeff Reidenauer
 - Alden Denny



Department of the Interior Marine Minerals

- USGS = Science
- BOEM = Science + Regulation



Critical Minerals Executive Order 13817

December 20, 2017



FEDERAL REGISTER
The Daily Journal of the United States Government



PD Presidential Document

A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals

A Presidential Document by the Executive Office of the President on 12/26/2017

PUBLISHED DOCUMENT

Executive Order 13817 of December 20, 2017

A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1. Findings. The United States is heavily reliant on imports of certain mineral commodities that are vital to the Nation's security and economic prosperity. This dependency of the United States on foreign sources creates a strategic vulnerability for both its economy and military to adverse foreign government action, natural disaster, and other events that can disrupt supply of these key minerals. Despite the presence of significant deposits of some of these minerals across the United States, our miners and producers are currently limited by a lack of comprehensive, machine-readable data concerning topographical, geological, and geophysical surveys; permitting delays; and the potential for protracted litigation regarding permits that are issued. An increase in private-sector domestic exploration, production, recycling, and reprocessing of

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Draft Critical Mineral List—Summary of Methodology and Background Information—U.S. Geological Survey Technical Input Document in Response to Secretarial Order No. 3359

Open-File Report 2018–1021

U.S. Department of the Interior
U.S. Geological Survey



List of Critical Minerals – May 2018

- Aluminum (bauxite)
 - **Antimony**
 - **Arsenic**
 - Barite
 - Beryllium
 - Bismuth
 - Cesium
 - Chromium
 - **Cobalt**
 - Fluorspar
 - **Gallium**
 - **Germanium**
 - Graphite (natural)
 - Hafnium
 - Helium
 - **Indium**
 - **Lithium**
 - **Magnesium**
 - **Manganese**
 - Niobium
 - **Platinum group metals**
 - Potash
 - **Rare earth elements**
 - Rhenium
 - Rubidium
 - **Scandium**
 - Strontium
 - Tantalum
 - **Tellurium**
 - Tin
 - **Titanium**
 - Tungsten
 - Uranium
 - Vanadium
 - **Zirconium**
- BOLD=**
Potential Marine Minerals

BOEM's Role in Offshore Critical Minerals

- BOEM oversees mineral development on Outer Continental Shelf (OCS)
 - Authority - OCS Lands Act (OCSLA) (43 U.S.C. 1331, et. seq.)
 - In process to develop a National Offshore Critical Mineral Inventory
 - As the nation's steward for these resources, BOEM must ensure that the removal of any mineral resource is done in a safe and environmentally sound manner
- Regulations - 30 CFR 580, 581, 582 (Prospecting, Leasing, and Operations on the OCS for Minerals other than Oil, Gas, and Sulfur)
 - Two Stage Leasing Process (Prospecting, Leasing)
 - Lack Statutory Authority to Lease Offshore US Territories and Possessions

EO 13817 – BOEM Responsibilities

EO 13817 directed the Federal Government to develop an interagency report, to be released soon. As part of that effort BOEM is involved with:

- ✓ Improving the geophysical, geological, topographical, and bathymetrical mapping of the U.S. and associated coastal and ocean territory
- ✓ Improving the discoverability, accessibility, and usability of geophysical, geological, topographic, and bathymetric data
- ✓ Providing recommendations to revise regulations and consider proposing legislation to facilitate offshore critical mineral development

Historic Lease Interest

- Commonwealth Northern Mariana Islands (2006)*
- Gorda Ridge, CA (2007)
- Guam (2007) *

*BOEM does not have the statutory authority to issue leases offshore the US territories or possessions



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14th December 2007

The Honorable Dirk Kempthorne
Secretary of the Interior,
Department of the Interior
1849 C Street, N. W.
Washington, D.C. 20240-0001

cc. Renee Orr, Roger Amato at MMS.

Dear Sir,

Re: Request for competitive marine minerals lease sale within the EEZ of the Continental United States of America.

I would like to request a competitive marine minerals lease sale, within the Exclusive Economic Zone of the Continental United States of America, under U.S. Code 30 C.F.R. 281.

We are making the request through our US subsidiary, Nautilus Minerals US Inc, a company incorporated under the laws of the State of Nevada (copy of Articles of Incorporation attached).

The area of the application is defined by the attached schedule and plan (annexes 1 and 2).

The minerals of interest to our exploration effort include, but are not limited to;

Gold, silver, copper, lead, zinc, molybdenum, nickel, cobalt, sulphur, iron, barite, antimony, selenium, platinoids, chrome, uranium and manganese.

www.nautilusminerals.com

TSKY:NUS

New Vision • New World • New Resources

International Seabed Authority (ISA)

- The ISA is comprised of 167 member states and the EU. Members are party to the 1982 UN Convention on the Law of the Sea
- Most formal scientific advice to the ISA comes through the Legal and Technical Commission (LTC), an organ of the Authority consisting of subject matter experts from member states



International Seabed Authority (ISA)

- The Legal and Technical Commission is responsible for tasks including review of applications of plans of work, supervision of exploration activities, and evaluation of EIS
- The LTC may solicit outside expertise, including independent scientific advice



ISA Headquarters, Kingston Jamaica

USGS Marine Minerals

- USGS uses oceanographic and geologic characteristics to define the most **permissive** regions for marine minerals in the global **ocean**
- The USGS **collects and analyzes** marine mineral samples to evolve **estimates** of potential mineral deposits, and demonstrate gaps in datasets
- The USGS works to **define and measure** oceanographic and environmental parameters that need to be assessed as industry moves toward extraction

USGS Marine Minerals

- Working with International Seabed Authority (ISA) since 2000
- Working with ISA through DoS since 2007
- Provide **sound science** to inform decision making
- Scientific **advisors** to delegations on the ISA First Council
- Involvement in workshops **defining mineral classifications** and **discussing environmental considerations**
- **Inform** US government on deep-ocean minerals

USGS Marine Minerals

We collect, analyze, and experiment on marine minerals resulting in:

- The first study on Arctic Ocean ferromanganese deposits (2017), multiple publications forthcoming
- More than 1000 crust samples from 25 different regions
- Studies on the three major nodule fields including the Clarion Clipperton Zone, the Peru Basin, and the Cook Islands
- Research on unique and heterogeneous sulfide deposits throughout the East, West, North and South Pacific regions, including within the US EEZ

USGS Marine Minerals

We use our expertise in geology and oceanography to inform:

- genetic models for different deposit types
- deposit distributions and conditions and environments of formation
- key deposit characteristics required to develop exploration tools, and determine the sizes of exploration and exploitation areas
- Potential environmental impacts of mining

Marine minerals of current global interest

- Polymetallic nodules (aka manganese nodules)*
- Ferromanganese crusts (aka cobalt-rich crusts)*
- Polymetallic Sulfides (aka seafloor massive sulfides)*
- Phosphorite deposits
- Metalliferous sediments
- Rare earth element rich muds

* Defined by ISA as marine minerals, eligible for exploration licensing

Marine minerals defined by the ISA

- Polymetallic nodules
 - Ferromanganese crusts
 - Polymetallic Sulfides
-
- The International Seabed Authority is currently signing exploration contracts, 29 to date, working on exploitation regulations and Regional Environmental Management Plans
 - **Enormous** permissive regions need exploration: 38 million km² nodules, 1.7 million km² crusts, 3.2 million km² sulfides

Petersen et al., 2016

Nodules

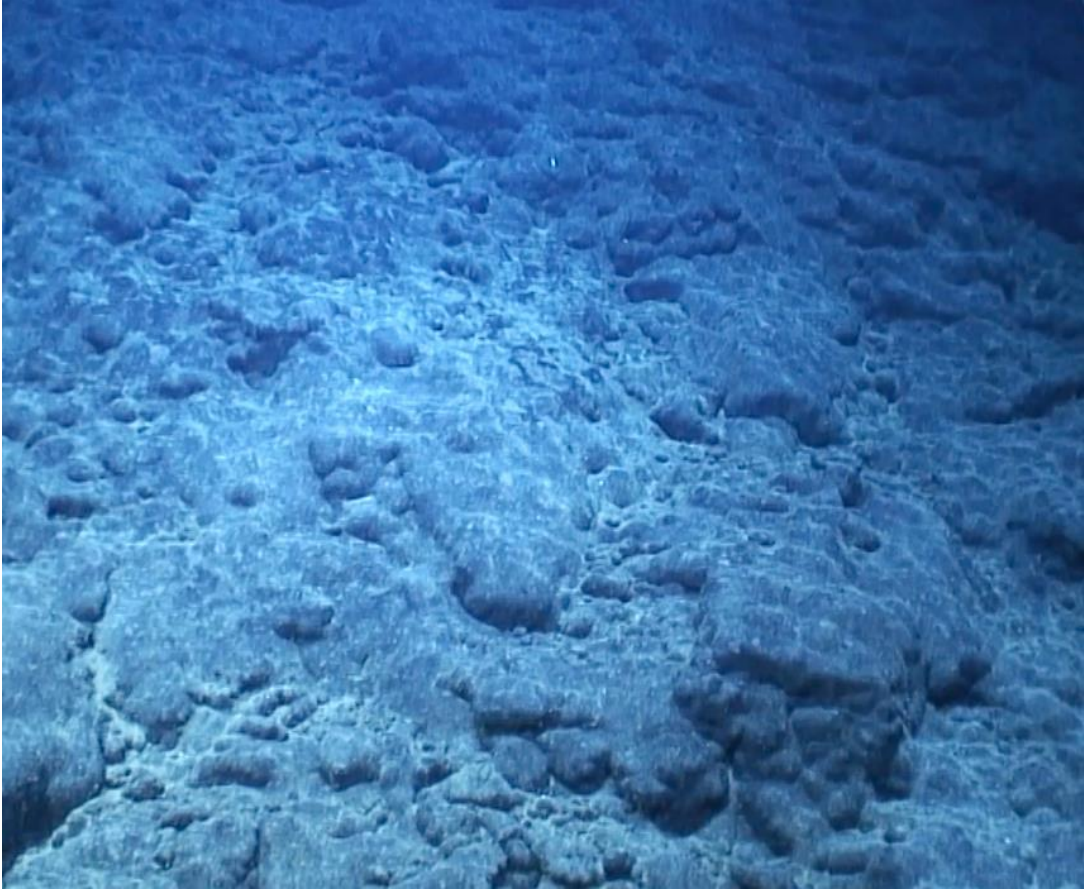


Nodules



- Occur on sediment-covered abyssal plains with low sediment flux at depths of 3500-6500 m
- Occur mainly at the seafloor surface
- Of interest for Ni, Cu, Co, Mn, possibly Ti, REY and Li
- No terrestrial analogue
- The ISA has issued 17 exploration contracts, with an additional one under consideration

Crusts

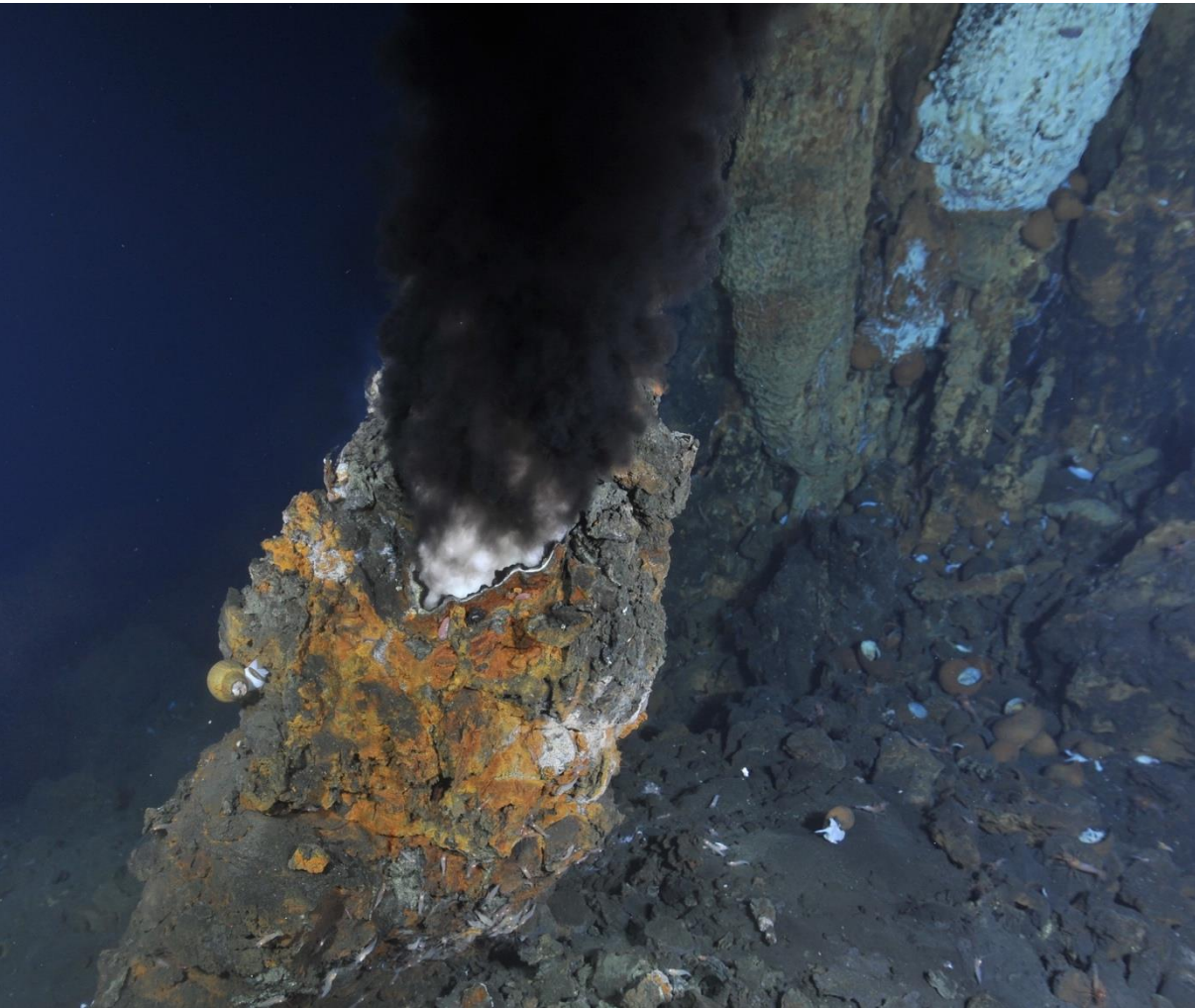


Crusts

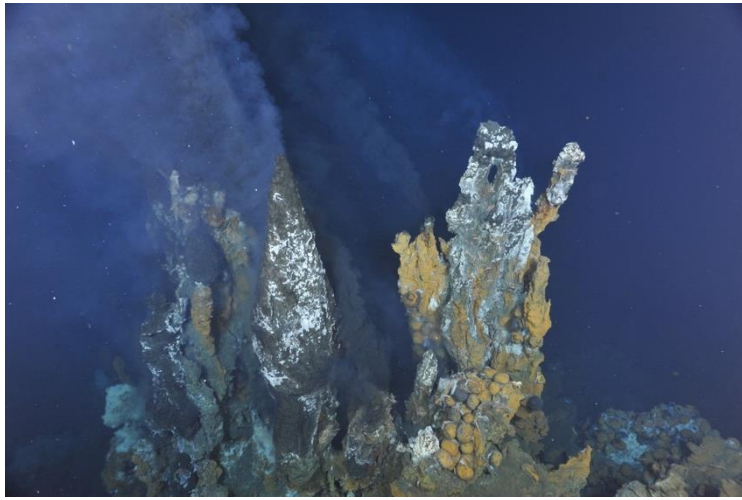


- Crusts occur on rock surfaces at depths of 400-7000 meters
- It is difficult to measure crust thickness *in situ* using current technology
- Of interest for Mn, Co, Ni, Cu, REY and possibly Te, Sc, Pt
- No terrestrial analogue
- ISA has issued 5 exploration contracts

Sulfides

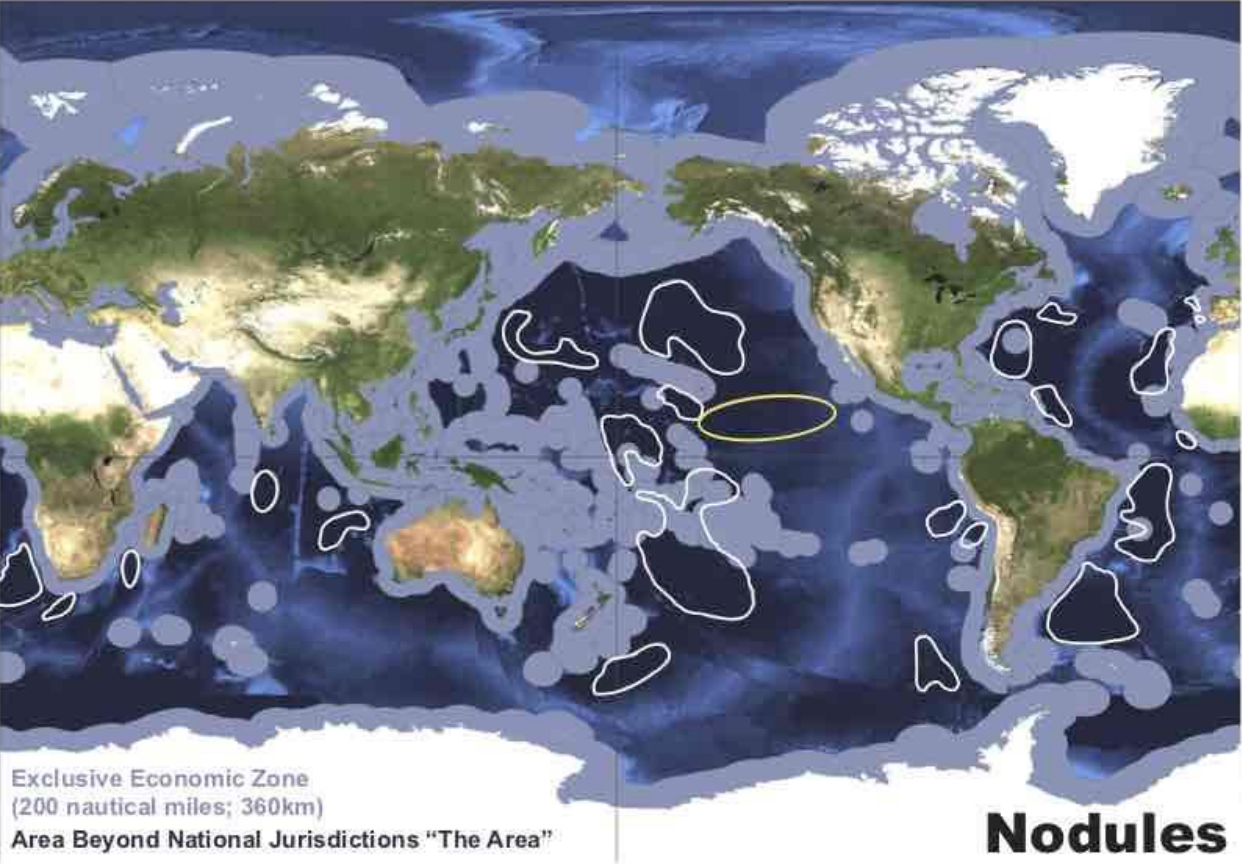


Sulfides



- Occur along 89,000 km of plate boundaries- spreading centers, arcs and back-arcs
- Sulfide deposits extend below the seafloor, and this third dimension is not currently well constrained, nor is the extent of inactive sulfides
- Highly heterogeneous, of interest for Cu, Zn, Au, Ag
- Analogous to terrestrial volcanogenic massive sulfide deposits
- ISA has issued 7 exploration contracts

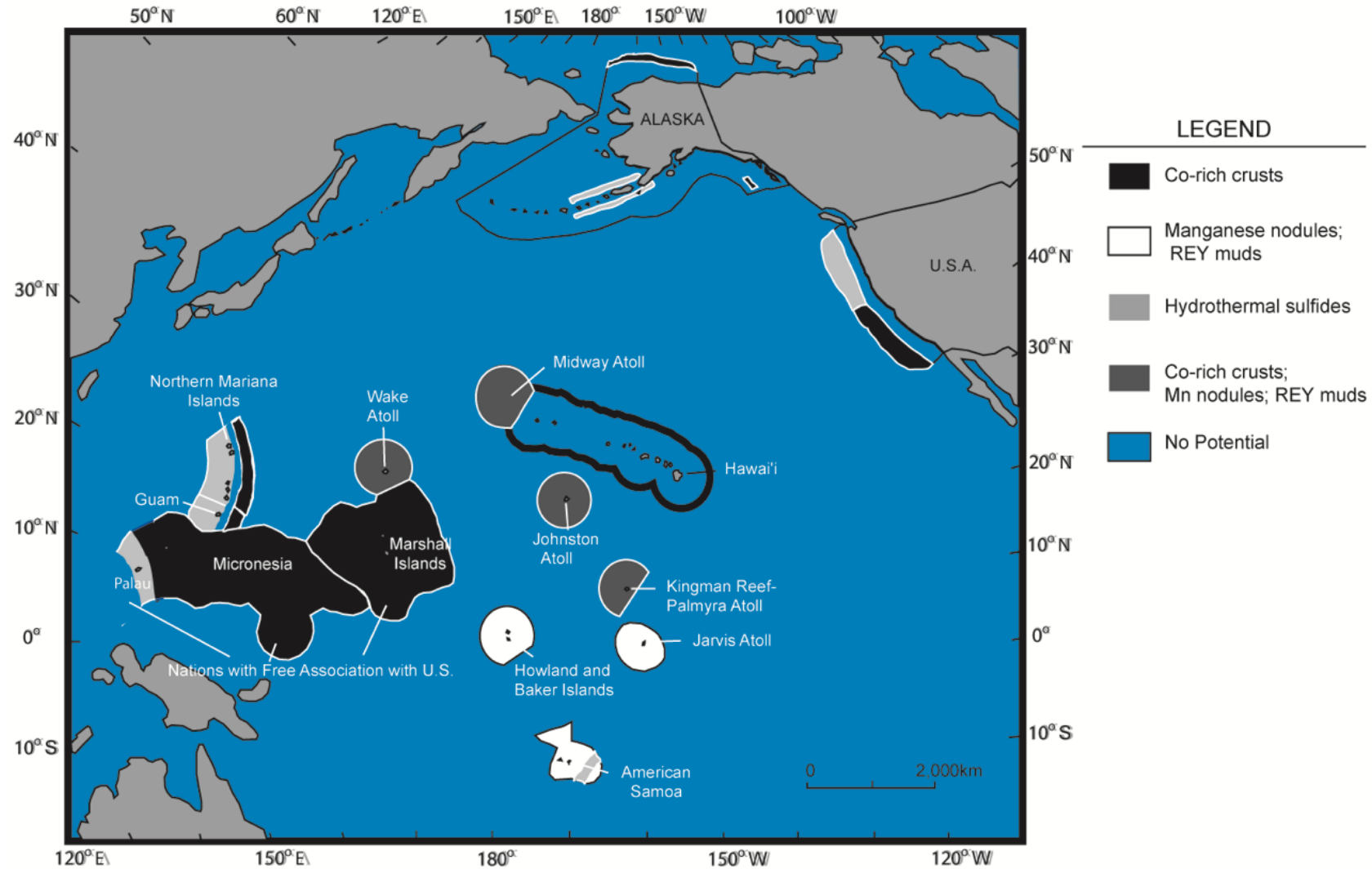
Globally permissive regions



Hein et al., 2013

- Permissive regions are outlined in white
- Clarion Clipperton Zone (nodules) and Prime Crust Zone (crusts) are outlined in yellow

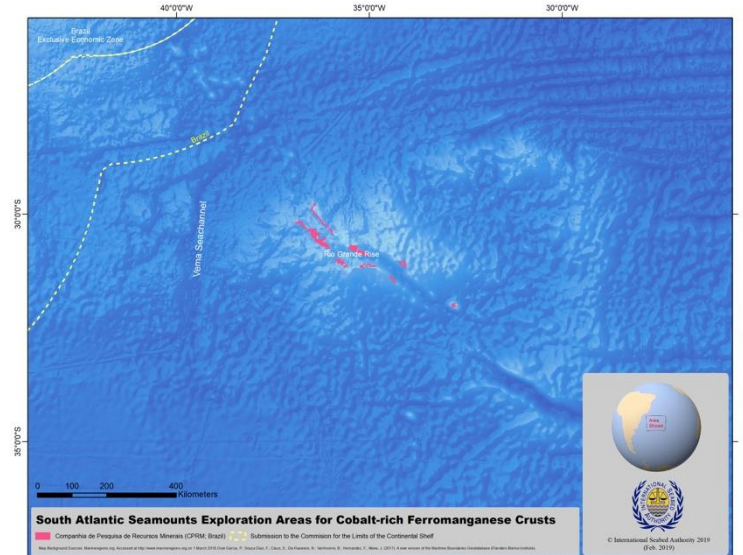
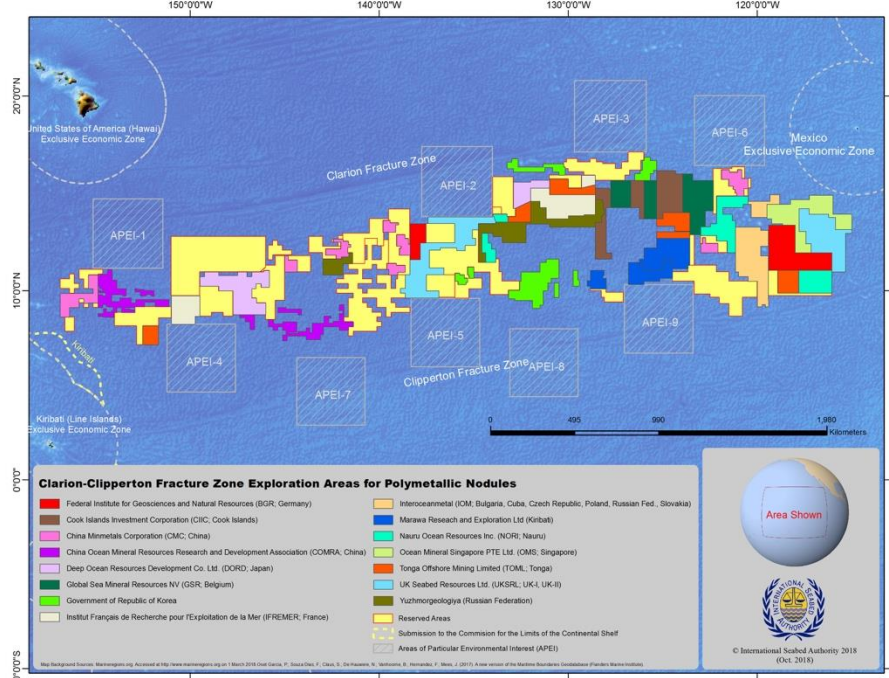
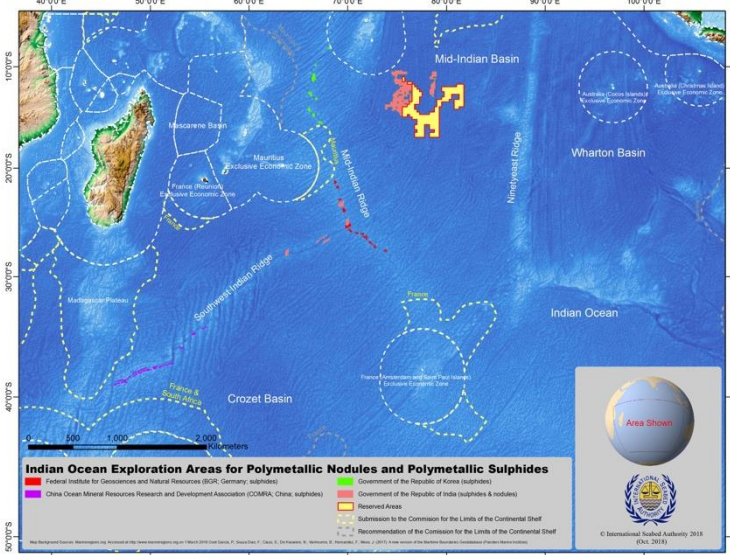
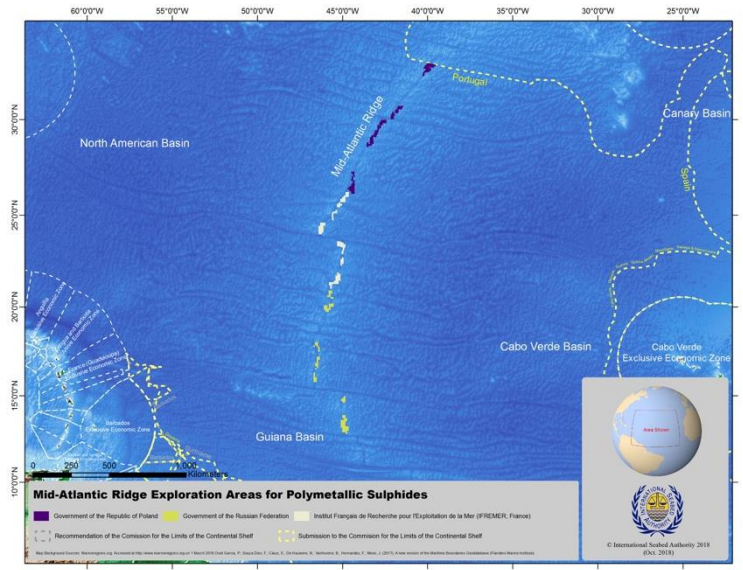
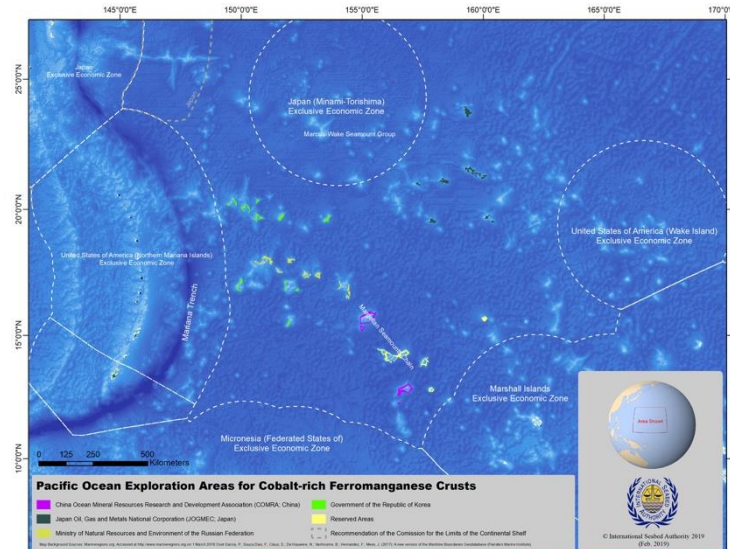
U.S. Pacific and Arctic Exclusive Economic Zone



Hein et al., 2005

Global contracts- International Seabed Area (i.e. The Area)

The ISA is currently issuing exploration contracts for polymetallic nodules, polymetallic sulfides, and ferromanganese crusts

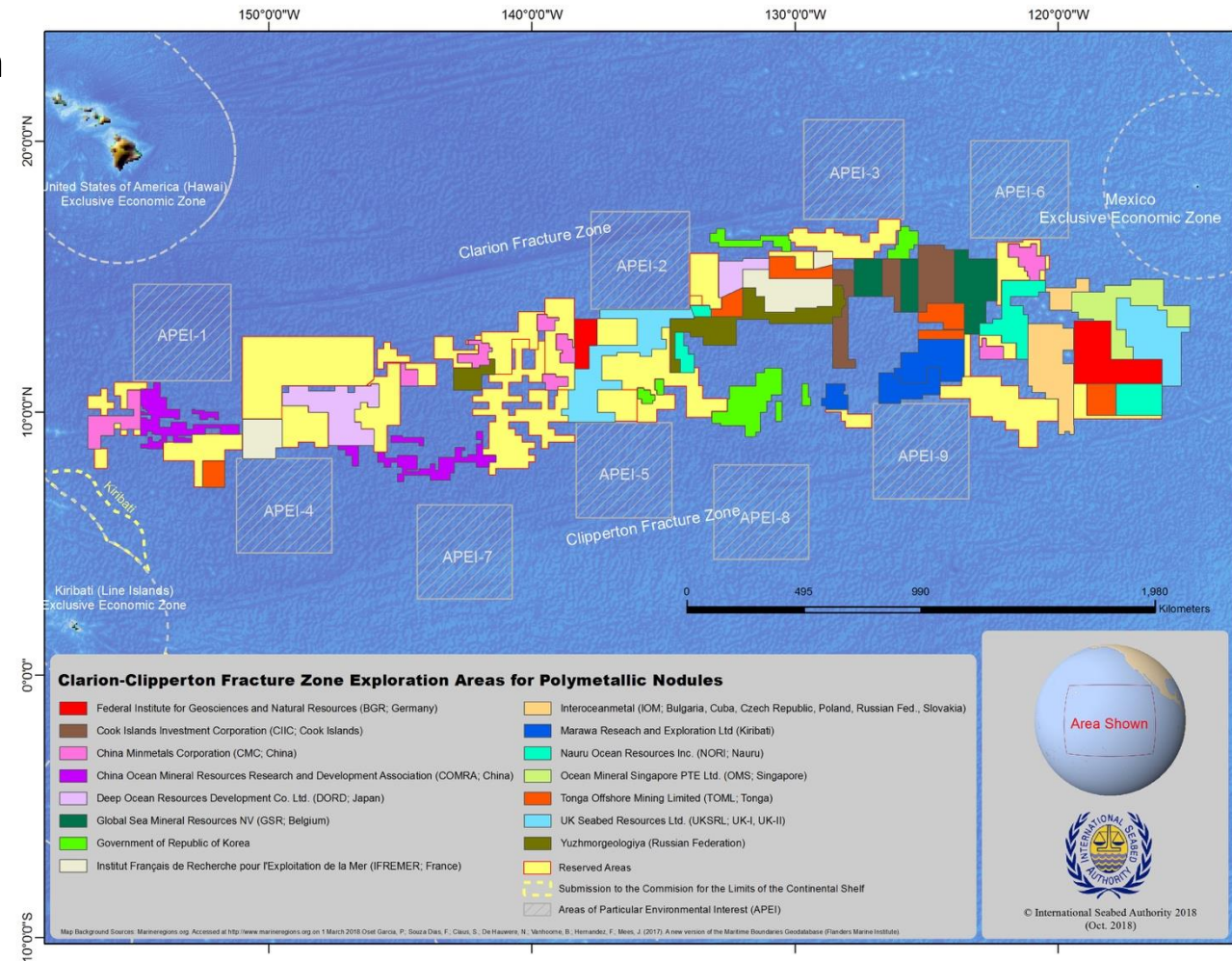


Global contracts- Clarion Clipperton Zone

- The ISA has issued 16 polymetallic nodule exploration contracts in the Clarion Clipperton Zone (CCZ)
- The CCZ is the only region for which a Regional Environmental Management Plan (REMP) has also been developed. REMPs will eventually be developed for all mineral contracting regions
- Global Seabed Mineral Resources (GSR, Belgium) is currently working on their second prototype nodule collector for use in the CCZ (pictured below)

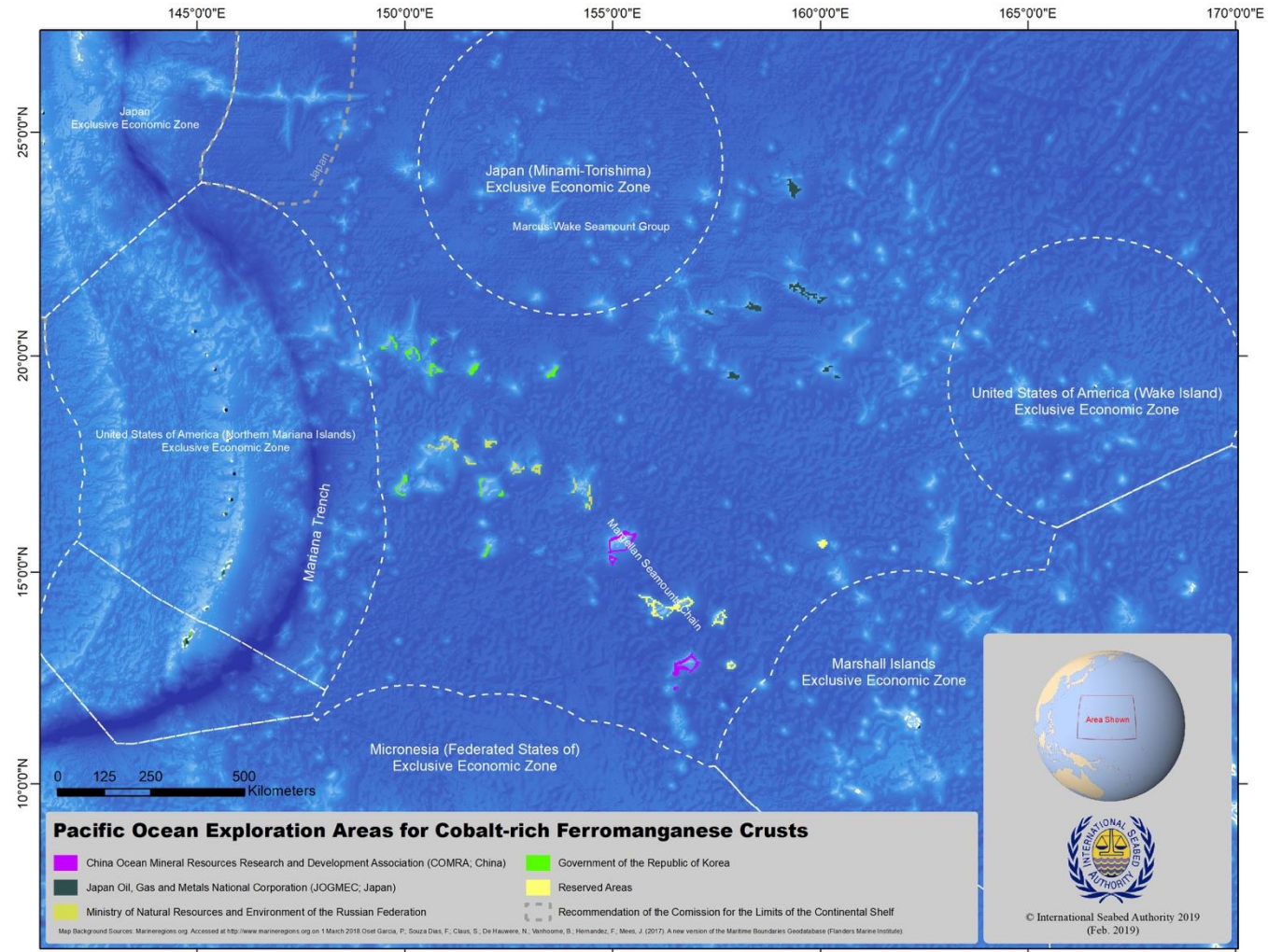


www.deme-group.com



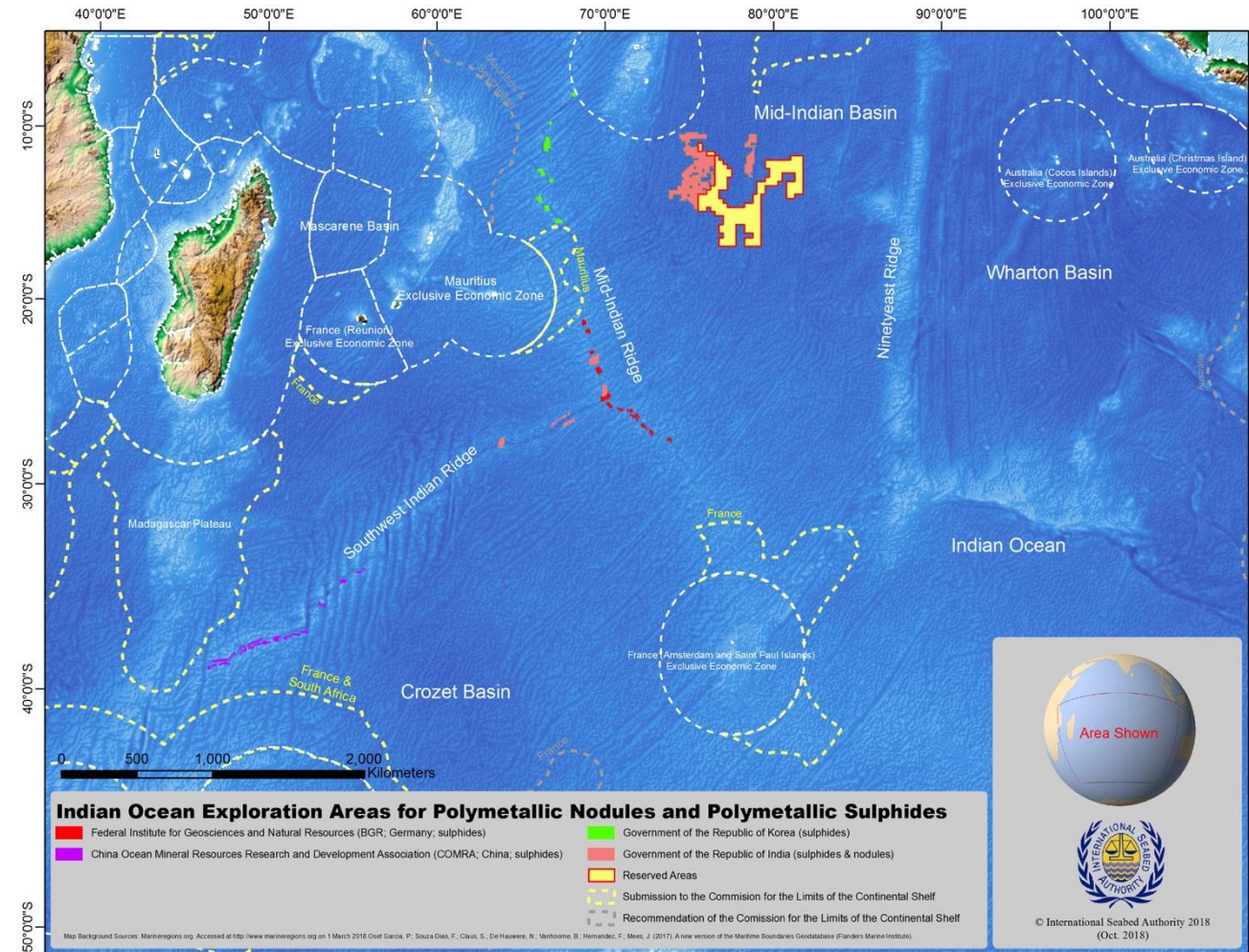
Global contracts- Pacific Ocean Crusts

- Four exploration contracts have been issued for Cobalt-rich Ferromanganese Crusts in the central and western Pacific
 - This region, containing the oldest and thickest crusts known, is known as the Prime Crust Zone (PCZ, Hein et al., 2009)
 - The PCZ overlaps parts of The Area and several countries Exclusive Economic Zones
- 46 % of the most favorable regions for Co-rich crusts are located in The Area



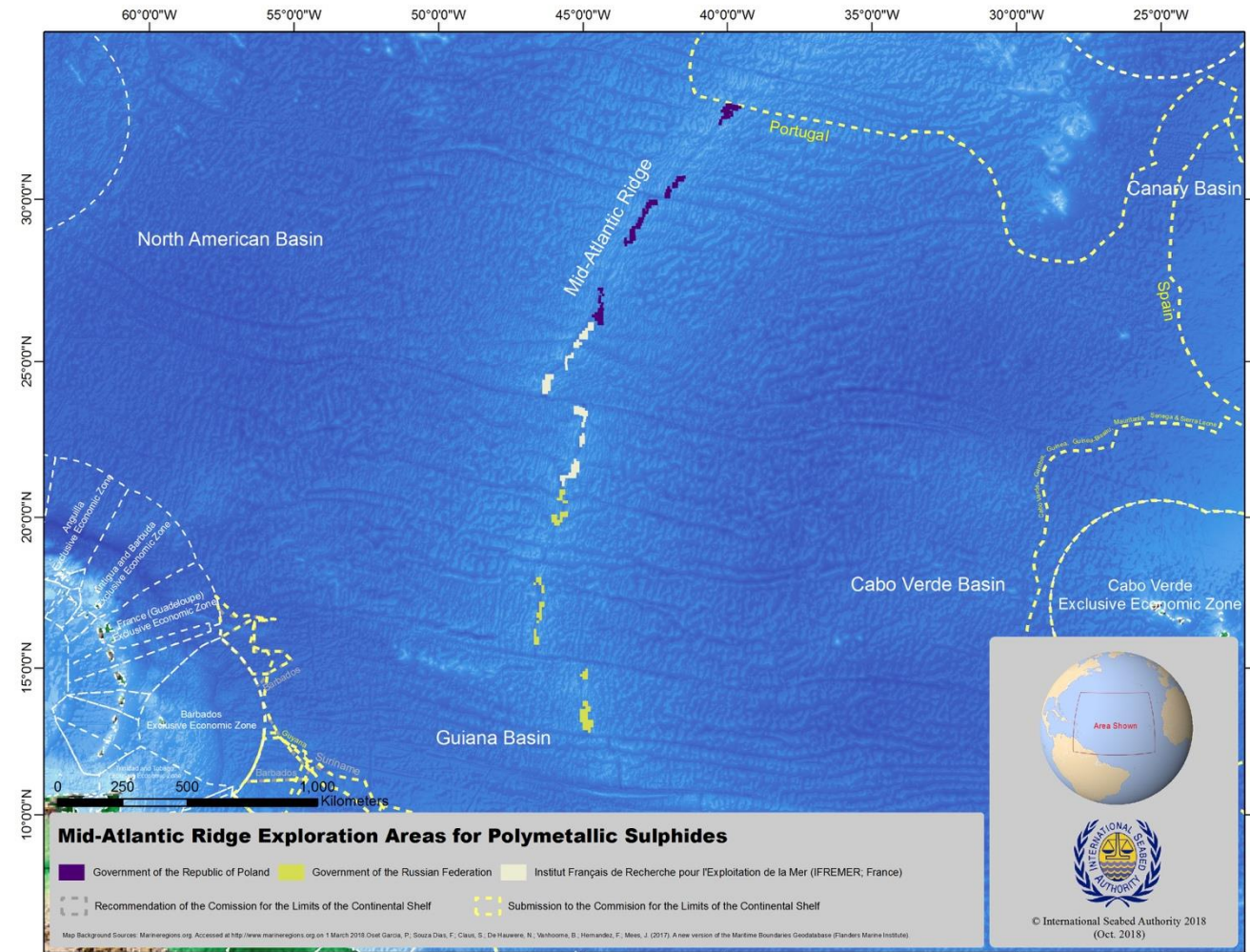
Global contracts- Indian Ocean

- Contracts for sites for polymetallic nodules and sulfides have been issued in the Indian Ocean
- 81 % of the most favorable regions for polymetallic nodules are located in The Area
- 59 % of known or suspected active hydrothermal sulfide deposits occur in The Area
- Exploration activities are increasing for inactive and off-axis seafloor sulfide deposits



Global contracts- Mid-Atlantic Ridge

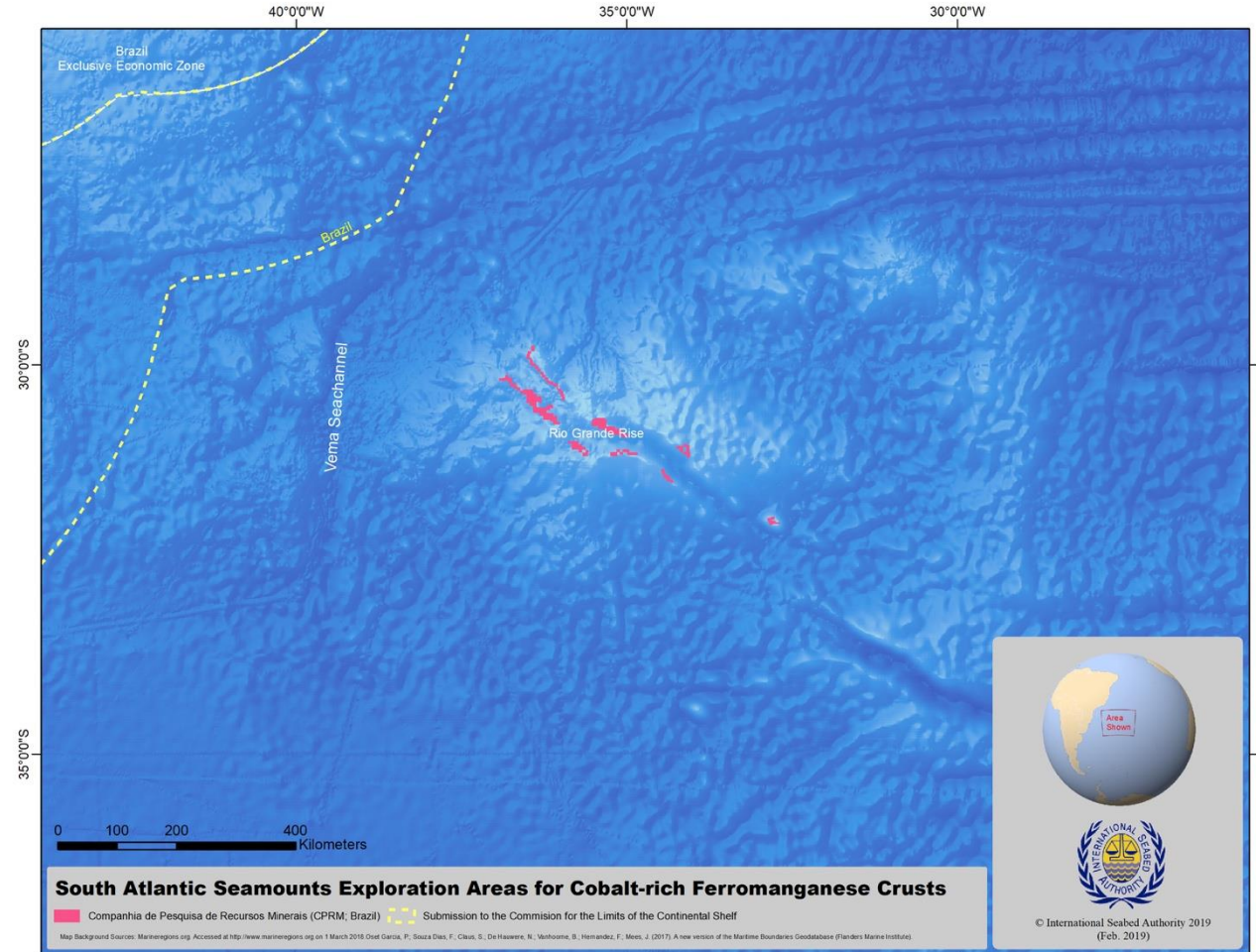
- Three exploration contracts have been granted along the Mid-Atlantic Ridge, all for Polymetallic Sulfides
- From North to South, contracts have been granted to the Government of the Republic of Poland, IFREMER (France), and The Government of Russian Federation
- Japan recently recovered 4 tons of sulfide minerals from within their own EEZ. It is estimated that 2 million tons per year will be needed for a viable sulfide mine



Global contracts- Rio Grande Rise

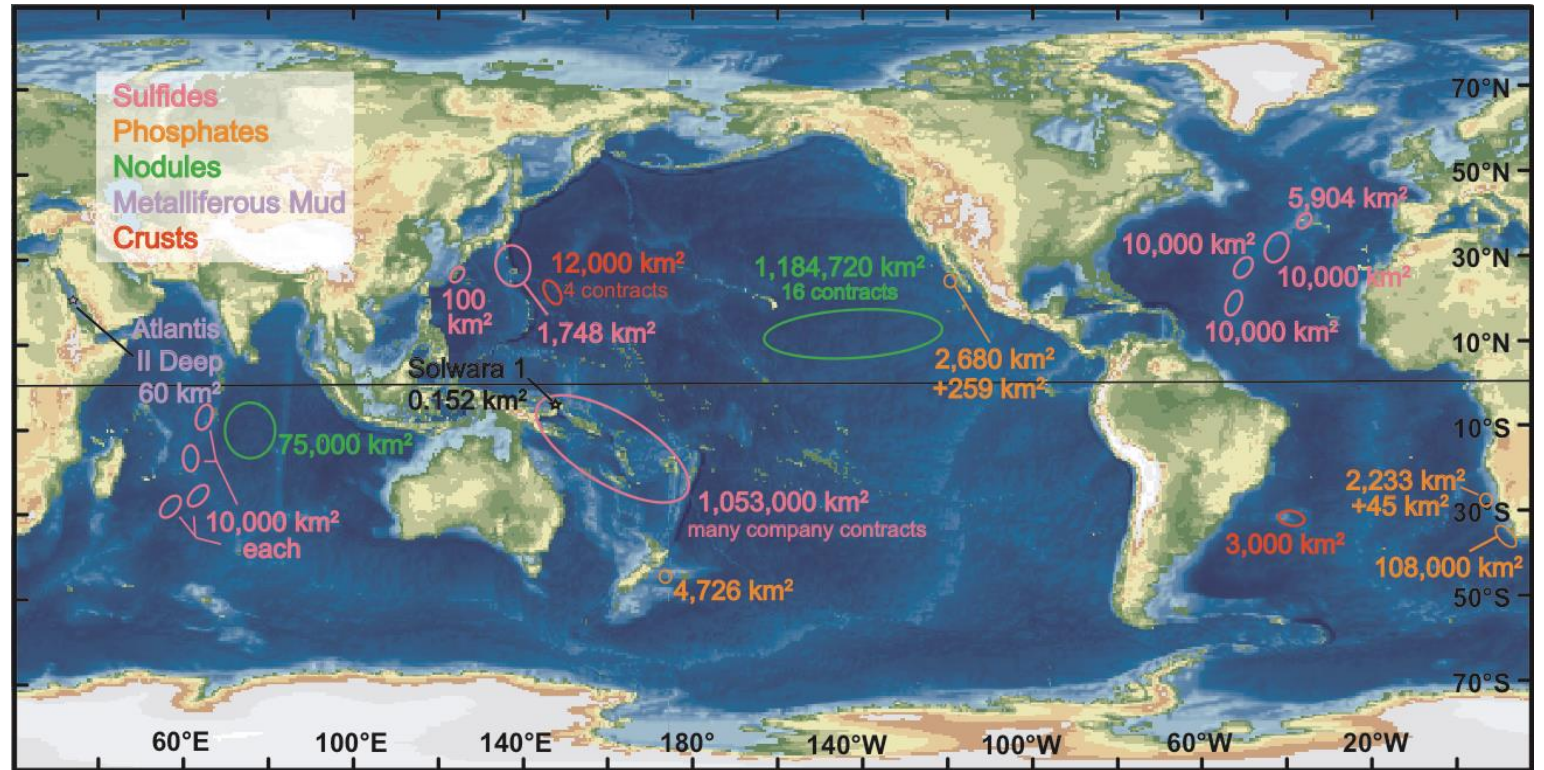
- There has been one contract issued for Cobalt-rich Ferromanganese crusts in the South Atlantic, to CPRM, Brazil
- The ISA approved the regulations for exploration for Cobalt-rich Ferromanganese crusts in 2012, and issued the first contracts in 2014
- Crusts are slower growing than nodules and have more surface area, allowing for greater enrichment in metals of interest

Hein et al., 2000



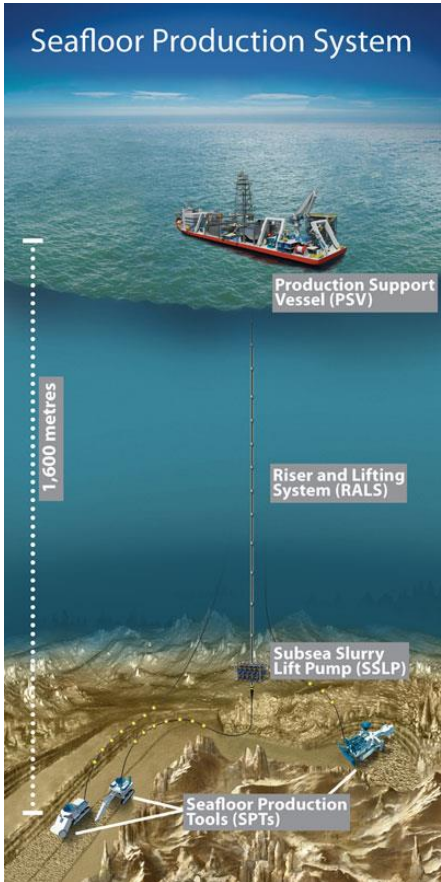
Global contracts-The Area and EEZs

- In total 2,525,000 km²
- Total contract area is 3.6 times the size of Texas
- Approximately 50% is in EEZs and 50% The Area



Modified from Hein et al., 2013

Environmental considerations



Nautilus Minerals graphic

The possibility of deep-sea mining has created both the **need** and the **means for more extensive baseline characterization** of the oceans and **deeper insight into ocean processes**

- **Nodules**- removal of substrate and abyssal fauna over large areas, sediment plume
- **Sulfides**- possible removal of substrate, possible sulfide mineral plume, local metal release and local acidification
- **Crusts**- possible removal of substrate and seamount fauna over large areas, possible release of substrate and oxide particles
- We collaborate with **academic, industry** and **government** scientists to consider how impactful these issues may be and if necessary, how to address them

Marine Minerals- Pacific Coastal and Marine Science Center

- Expertise includes mineral analyses and water-rock interactions
- Capabilities include powder x-ray diffraction, UV-visible spectrophotometry, Fourier-transform infra-red spectroscopy, and electrochemical analyses. We perform element analyses and isotopic age dating
- Leverage ships of opportunity and collaborative funding to collect samples
- Collaborate locally with the USGS Menlo Park, UC Santa Cruz, Stanford University, Stanford Synchrotron Radiation Labs, and the Advanced Light Source (Berkeley) to perform electron microscopy, x-ray microdiffraction, micro x-ray fluorescence, and micro x-ray absorption spectroscopy, and experimental work
- Current projects regarding hydrothermal manganese and metalliferous sediments in different regions of the Arctic, ferromanganese crusts in the equatorial Pacific, the potential mining impacts of ferromanganese nodules, and many more

Further information

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<https://www.usgs.gov/centers/pcmsc/science/global-ocean-mineral-resources>

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