

## **Deep Sea Mining, Opportunities for India and Urgency to Act**

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### **Abstract**

With the dawn of the Information age demand for Rare Earth Elements has shot up manifold. While China has managed to maintain a monopolistic grip on global production and supply of Rare Earth Elements, other major players such as the USA, Europe, Japan and India are now waking up. The aim of this paper is to underline the national importance of having secure supply of Rare Earth Elements and the opportunities that are available via Deep Sea Mining operations in production of such elements. Also various tools and techniques used for such operations are discussed.

**Keywords:-** Rare Earth Metals, Polymetallic Nodules, Sulfides Nodules, Cobalt Crust, United Nations Convention on the Law of the Sea (UNCLOS), International Seabed Authority (ISA), Belt and Road Initiative (BRI), Remote Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs), Hybrid underwater robotic Vehicle (HURVs).

### **1. Introduction**

As Electronics, Microchips and Computers have found their uses in all aspects of life the uses of Rare Earth Metals have increased exponentially, Metals such as Lanthanum, Neodymium, Europium, Erbium, Samarium have become very important and highly sought after. Other Metals such as Cobalt, Nickel, Copper, Molybdenum and Yttrium are also used in similar applications. All such Metals are available at the seabed and can be extracted for civilian as well as military uses.

#### **Deposits at the seabed.**

Various deposits are available at the sea bed but the major deposits are as follows.

- Polymetallic Nodules: Often these nodules are also referred as ferromanganese nodules or manganese nodules. They are formed at the seabed by deposition of iron and manganese hydroxides layer by layer on top of each other over a core. They mostly contain silicates and iron and manganese oxides. These nodules are found in deep sea as well as shallow waters and they contain an abundance of Nickel, copper and Manganese along with other Rare Earth Elements. Their formation takes millions of years with an approximate growth rate of 1 – 3 mm per million years. (Toro et al., 2020) (Joseph, 2017)

- Sulfides Nodules: Hydrothermal Vents at the sea bed result in deposition of sulfides of various Metals such as silver, gold, copper, manganese, cobalt, and zinc. Active or extinct Hydrothermal Vents at the sea bed have a large collection of such nodules around them. They are formed due to the interaction of sea water with hot volcanic rocks. Such hydrothermal vents are mostly found at the depth of 1000 to 4000 meters in the deep sea. (WOR, 2014)
- Cobalt Crust: As the name suggests this is a hard layer of rock deposit with abundance of cobalt in it. These are formed very slowly over millions of years with formation rate as low as 1 to 5 mm per million years. They are formed on exposed rock surfaces and unlike nodules they are rigidly attached to the surface making it more difficult to mine them. They also act as shelter to various marine animals and their mining is going to result in loss of various marine eco-systems. Such crusts are mostly found at the depth of 600 mtrs to 7000 mtrs at the seabed. (WOR, 2014)

#### **Elements available at the sea bed and their applications**

Following is a comprehensive list of Elements that can be mined via deep sea mining along with their civilian as well military application.

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**Table 1: Elements available at the sea bed and their applications.**

| SI No. | Element    | Symbol | Application   |   |
|--------|------------|--------|---|---|
|        |            |        | Civilian  | Military  |
| 1      | Lithium    | Li     | Battery, Power storage  | Power source for various Automated weapons                |
| 2      | Aluminum   | Al     | Aerospace Industry, Conductors, Heat Exchangers                               | Fuselage of various Aircrafts                             |
| 3      | Barium     | Be     | Fireworks, glass manufacturing, drilling fluids                               | Radar-absorbing materials                                 |
| 4      | Bismuth    | Bi     | Cosmetics, alloys and fire extinguishers                                      | Production of bullets, Cold fusion reactor.               |
| 5      | Boron      | B      | Rocket Fuel Igniter   | Various missiles and weapon systems                       |
| 6      | Cadmium    | Cd     | Rechargeable batteries, pigments, corrosion-resistant plating                 | Ammunition  |
| 7      | Calcium    | Ca     | Medical, Steel Production   | NA  |
| 8      | Chromium   | Cr     | Stainless Steel, Alloy Steel with Creep Resistance                            | High temperature Alloys, Turbines, Jet Engines            |
| 9      | Cobalt     | Co     | High temperature alloys, High-speed steel, Li-ion Batteries, Permanent Magnet | High temperature Alloys, Turbines, Jet Engines            |
| 10     | Copper     | Cu     | Conductor, Heat Exchangers  | Power Generation and transmission                         |
| 11     | Gallium    | Ga     | Semiconductors, LEDs, solar panels  | High-temperature solders, thermal imaging devices         |
| 12     | Gold       | Au     | Jewelry, electronics, dentistry, monetary standard                            | Electronic components, connectors, coatings for equipment |
| 13     | Iridium    | Ir     | Spark plugs, fountain pen nibs, platinum alloys                               | Electronic components, missile guidance systems           |
| 14     | Iron       | Fe     | Ship Building, Construction   | Ship Building   |
| 15     | Lanthanum  | La     | Lighting, catalysts, optical glasses  | Electronic components, alloys                             |
| 16     | Lead       | Pb     | Lead Acid Batteries, weights for lifting, cable sheathing                     | Radiation protection, ammunition                          |
| 17     | Magnesium  | Mg     | Production of mobile phones, laptops etc                                      | Production of various Human interface devices             |
| 18     | Manganese  | Mn     | Fertilizers, Ceramics, High temperature alloys                                | High temperature Alloys, Turbines, Jet Engines            |
| 19     | Mercury    | Hg     | Thermometers, Barometers, Manometers, Dental amalgams, fluorescent lighting   | Liquid mirror telescope, Explosives and Munitions         |
| 20     | Molybdenum | Mo     | Alloying agent, lubricants, catalysts   | Armor plating, aircraft parts, gun barrels                |
| 21     | Nickel     | Ni     | Low temperature Steel, Wear resistance steel alloys, Permanent Magnet         | Cryogenic Fuel Tanks, Cryogenic rocket motors             |

| Sl No. | Element    | Symbol | Application   |   |
|--------|------------|--------|---|---|
|        |            |        | Civilian  | Military  |
| 22     | Palladium  | Pd     | Catalytic converters, electronics, jewelry                        | Electronic components, catalysts                                |
| 23     | Phosphorus | P      | Fertilizers, Safety Matches, Steel Production                     | Flares, LED panels  |
| 24     | Scandium   | Sc     | SunLight lamps, Aerospace   | Airplane Fuselage, Russian MiG Fuselage                         |
| 25     | Silicon    | Si     | Medicinal, various plasticware, Microchips, Solar Panels          | Various microchips.   |
| 26     | Silver     | Ag     | Jewelry, photography, electronics, bactericide                    | Electronic components, mirrors, medical equipment               |
| 27     | Sodium     | Na     | Soaps, Paper, Detergents, Ceramics, Medicinal                     | NA  |
| 28     | Strontium  | Sr     | Fireworks, pyrotechnics, medical imaging                          | Flares, tracer ammunition, radiation detection devices          |
| 29     | Tellurium  | Te     | Alloys, solar panels, electronic components                       | Electronic devices, sensors                                     |
| 30     | Thallium   | Tl     | Photocells, manufacturing of glass, rat and ant poison            | Infrared optics, Bio weapons.                                   |
| 31     | Tin        | Sn     | Soldering alloys, food packaging, corrosion-resistant plating     | Ammunition  |
| 32     | Titanium   | Ti     | Aerospace Industry, High temperature application                  | Airplane Fuselage, SR 71 Black bird                             |
| 33     | Tungsten   | W      | Light bulb filaments, high-speed tools, armor-piercing ammunition | Armor-piercing ammunition, armor plating, electronic components |
| 34     | Vanadium   | V      | Steel Alloys, Nuclear Reactors                                    | Nuclear Propulsion for Aircraft Carrier                         |
| 35     | Ytterbium  | Yb     | Laser technologies, medical treatments, materials                 | Laser-based targeting, communication systems                    |
| 36     | Yttrium    | Y      | LED phosphors, ceramics, lasers                                   | Missile guidance systems, aircraft engines                      |
| 37     | Zinc       | Zn     | Galvanizing, batteries, alloys, cosmetics                         | ammunition, brass casings                                       |
| 38     | Zirconium  | Zr     | Nuclear reactors, ceramics, alloys                                | Armor plating, nuclear submarines, missile components           |

As evident from Table 1 a large number of these metals have Military applications, also they are essential for production, storage and utilization of renewable power.

#### Regulations Concerning Deep Sea Mining

There is no single convention so far that is dedicated to control of exploration and exploitation of Deep-Sea resources at high seas, but as of now the mining operation is controlled as per following.

- United Nations Convention on the Law of the Sea (UNCLOS): Under this convention the maritime boundaries of a nation are determined. Also, the

Maritime boundaries of a nation are further divided into various zones as shown in the figure below. (UNCLOS, 1982)

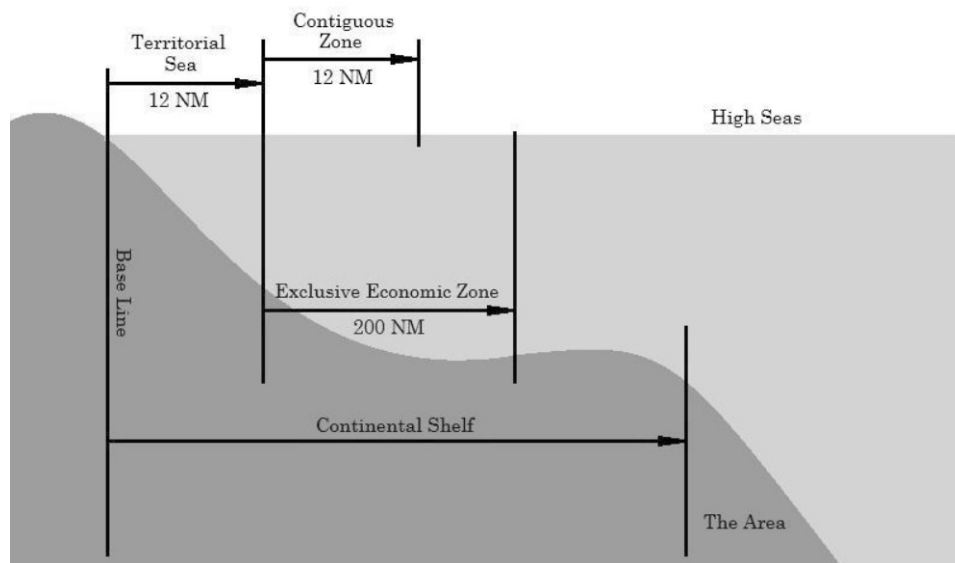


Figure 1: Maritime Zones as per UNCLOS

### 1. Territorial Sea

Up to 12 nautical miles from the baseline. All Foreign Flag Vessels have the right to innocent passage. Coastal states may exercise jurisdiction if the vessel is suspected of illegal activity. The Coastal State has sovereign rights over the Seabed, Subsoil, Water column and Air space.

### 2. Contiguous Zone

Up to 12 nautical miles beyond territorial sea. The coastal state has jurisdiction to prevent violations of its Customs, Immigration or sanitary laws.

### 3. Exclusive Economic Zone (EEZ)

Up to 200 nautical miles beyond the territorial sea. All States enjoy freedom of navigation while the coastal state enjoys control over exploration and exploitation of living and non-living resources of the water column and the continental shelf.

### 4. Continental Shelf

Not to exceed 350 nautical miles from the baseline or not to exceed 100 nautical miles from 2500 meters Iso bath. The coastal state enjoys control over exploration and exploitation of living and non-living resources of the continental shelf and the subsoil. Beyond 200 nautical miles the state has to make a submission to the commission for exploration and exploitation of natural resources.

### 5. High Seas

Water column beyond national jurisdiction.

### 6. The Area

Seabed and the subsoil beyond national jurisdiction. Exploration and exploitation of the non-living resources at the seabed and subsoil are under International Seabed Authority.

It is important to note that the United States of America has not signed the UNCLOS convention. China on the other hand signed the convention in 1996 after more than a decade of negotiation but threatens to withdraw every now and then. (Wang, 2016)

International Seabed Authority (ISA): ISA was established in 1994 under the United Nations Convention on the Law of the sea. All deep-sea mining exploration and exploitation related activities are conducted through ISA. ISA is responsible for protection of Marine Environment, it monitors and controls all deep-sea activities in the Area. (ISA, 1994)

### Various tools and techniques used for sea bed exploration and exploitation.

The deepest free dive ever made by a human was on 18/19 September 2014 by Ahmed Gabr in Dahab in the Red Sea to a depth of 332.35 meters as reported by the Dive Magazine. Although the dive was impressive, it is a long way from the deep-sea mining depths. With the development of deep-sea diving capsules or manned underwater vehicles, we can now go down to the deepest points in the ocean, such dives are mostly recreational or done for record breaking only they are very expensive for them to be used for deep sea exploration. (Dive Magazine, 2014)

### Deep sea Exploration

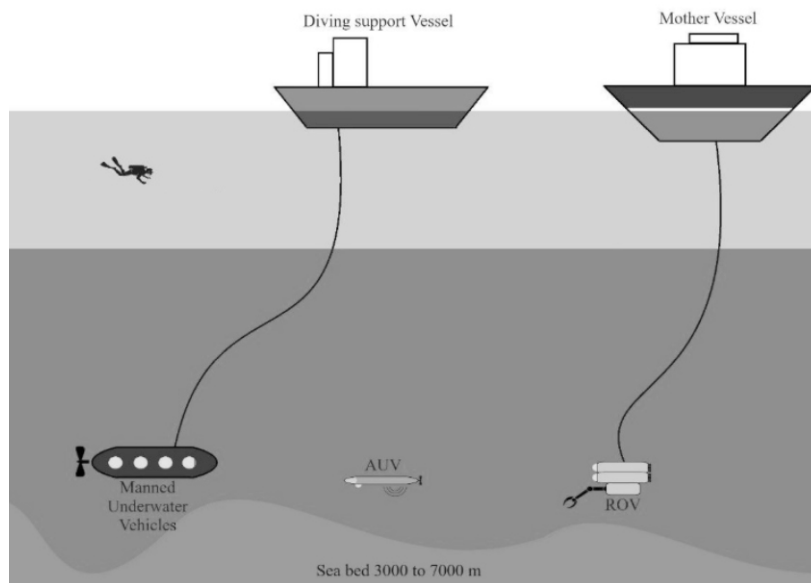


Figure 2: Deep Sea Exploration

Manned underwater Vehicles become very complex and expensive since they require life support systems, also they pose a serious risk to operators as well. The most economical and effective deep-sea exploration vehicles are “Remote Operated Vehicles (ROVs)”, “Autonomous Underwater Vehicles (AUVs)” and Hybrid underwater robotic Vehicle (HURVs). (Wu, 2017)

- **Remote Operated Vehicles (ROVs):** These Vehicles are Remotely operated by an operator, as radio communication under the water can work only for short distance These Vehicles are always connected to the mother ship using a wire/cable also referred as an umbilical cord. If the cable breaks the ROV will be lost to the sea. Further all ROVs are divided into four different classes based on their application and size.
  - a. Observation class: They include Vehicles upto 100 kgs weight with max power consumption around 15 KW and approximate diving depth of 300 mtrs only. They are mostly used for exploration and survey purposes only.
  - b. Light Work Class: ROVs between 100 to 1000 kgs with power consumption up to 55KW. They are deployed up to the depth of 1000 mtrs.
  - c. Work Class: Used for various work to be done at the seabed such as laying down underwater pipelines, cables, construction etc. Maximum operational depth is limited to 3000 mtrs.
  - d. Heavy work class: Highly specialized vehicles used up to the depth of 5000 mtrs with approx. power requirement of 110 KW.

An obvious flaw with ROVs is that they require constant human supervision and are prone to human error,

also large communication cables present their own challenges. Often there is a significant time delay in communication which results in slow and sluggish operation.

**Autonomous Underwater Vehicles (AUVs):** These are automated vehicles that can be launched from a mother ship but do not require an umbilical cord as they can navigate by themselves using autonomous control systems. They are launched with specific goals and time frames. Once they have completed said goals, they autonomously rendezvous with the mother ship. They are also used for surveillance and military applications.

Even though AUVs are excellent underwater tools for Deep Sea mining but their application is limited to exploration roles only this is due to the limited battery capacity (power storage) that they have. With development in power storage techniques, we might see AUVs carrying out more heavy-duty roles as well. (Xiang et al., 2015)

- **Hybrid underwater robotic Vehicle (HURVs):** They are a combination of ROVs as well as AUVs Such Vehicles can change operational modes at sea combining advantages of both ROVs and AUVs. They are also the most commonly used tools for deep sea mining operations. The most important feature of such vessels is that they can be recharged under water just by reattaching the Umbilical cord. (Xiang et al., 2015)

#### Deep sea mining Techniques.

Deep sea mining operations are normally carried out in three steps as follows.

- **Prospecting:** This is the planning stage where various large mining corporations in collaboration with coastal

states and in approval with international seabed authorities start researching and estimating various seabed reserves. Budget estimates are drawn up and scope of the mining operation is decided at this stage, based on present and future demand estimates of various products.

- **Exploration:** At this stage resource assessment and

pilot mining work is started. Various AUVs, ROVs and deep towed photography instruments are used in combination of techniques such as echo-sounding, Sonar Scanning, Gravity exploration, Seismic exploration, Magnetic exploration, Electrical exploration to map the ocean floor and estimate the quantity of deposits. (Guo et al., 2023)

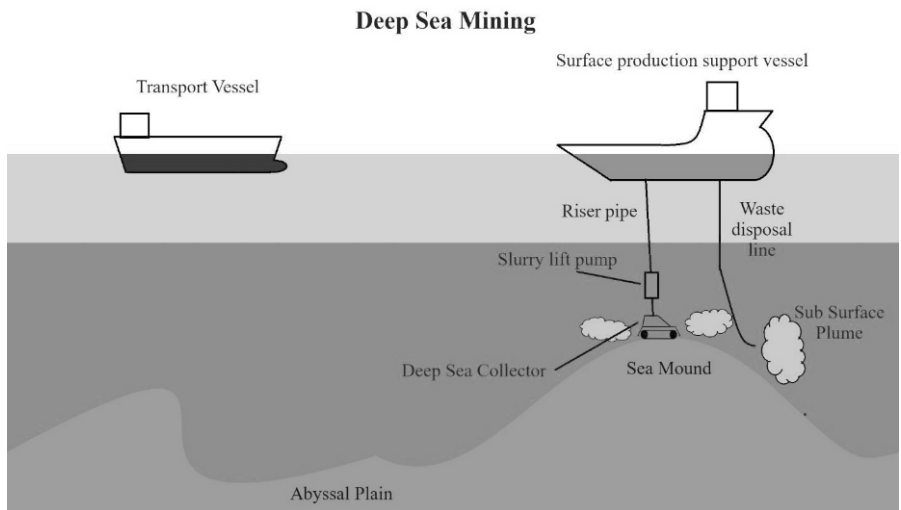


Figure 3: Deep sea Mining Operations

- **Extraction:** Extraction of nodules is easier compared to extraction of cobalt crust. Nodules can be simply picked up from the seafloor as they are not firmly attached to anything, but the cobalt crust is rigidly attached to the rock surfaces and the same needs to be excavated before it can be picked up. Various sea floor collectors are used to collect nodules/excavated sea crust. All collected solids are then pumped using a slurry lift pump through the riser pipe to a surface production support vessel. At the surface nodules/excavated crust is separated from the sea water, waste water and mud mixture are then drained

back to the sea. Nodules or excavated crust is then delivered to a transport vessel for further processing.

**Geo Politics of Rare Earth Elements**

As evident from Table 1 Rare Earth Elements as well as Deep Sea mining are both very useful for various High-tech Military Hardware as well as Renewable Energy generation and storage equipment. Nations like China realized this long back and shaped their policies accordingly. Today China controls nearly 68% of global Rare Earth Element production.

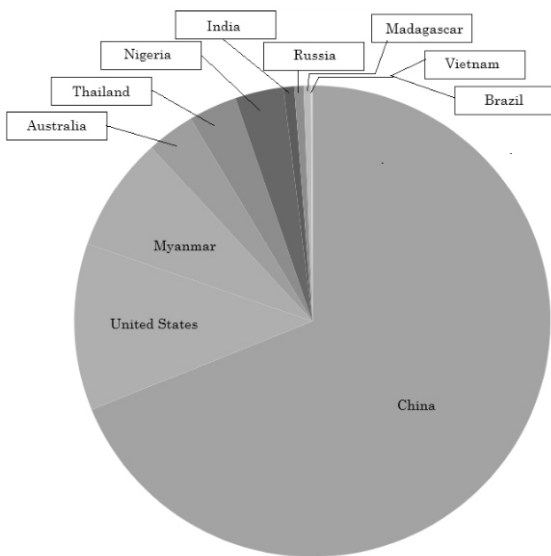


Figure SEQ Figure \\* ARABIC 4: Rare Earth Production by various countries

As evident from Figure 4, China controls a major chunk of Rare Earth Element production. China doesn't just control Rare Earth Reserves within its territory but also it has also secured mining rights in various African countries. China uses its control over Rare Earth to strong arm various nations around the globe.(Statista, 2024)

In 2010 China banned export of Rare Earth Elements to Japan following a territorial dispute in the south China sea. China's response was not just limited to the export ban, but President Xi also managed to publicly humiliate then Japanese prime minister Shinzo Abe. The ban brought Japan to its knees and the Abe administration was left with no choice but to agree to Chinese demands. Amid present day tariff war against US president Donald Trump China has again started using supply of rare earth as a bargaining chip. (Mulgan, 2014) (Waldersee & Steitz, 2025)

### Geopolitics of Deep-Sea mining

Similar to Rare Earth mining on land China is trying to control Deep Sea Mining as well. China has used its Checkbook diplomacy by projects such as Belt and Road Initiative (BRI) to gain influence on a large number of nations across the globe. Small Nations are given loans for projects that do not make economic sense and the host country often defaults that particular loan putting it firmly under Chinese influence. (Singh, 2023)

With large number of small nations under Chinese influence and debt China has built up a strong vote bank in United Nations. With the help of its large vote bank, China is controlling various decisions made by the

International Seabed Authority (ISA) in its favor. (Kardon & Camacho, 2023)

So far China has managed to secure more than 30 licenses across five Ares for deep sea mining exploration and with this continued trend it is likely to dominate Deep Sea Mining as well as the Rare Earth supplies across the Globe. (Lily kuo, 2019)

### Conclusion

- Vast amount of Rare Earth Elements and other metals are available at the sea bed, we need to develop economical and environment friendly techniques for extraction by extensive research and development in this field.
- India needs to start making serious gains in the field of deep-sea mining as well as Rare Earth Production for securing safe and stable supply of Rare Earth Elements.
- Additional research and training are required in the Maritime and oceanographic field of studies.
- ROVs, AUVs and HURVs are going to be in large demand for the next decade or more. Although the Govt. of India has taken considerable steps under Atmanirbhar Bharat, more budget allocation and initiation is required in this sector.
- The Govt. of India needs to promote training and innovation in the field of deep-sea diving.
- Further work is required on deep sea exploration techniques.

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