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DEEP-SEABED MINING - ADVANTAGES AND CHALLENGES OF EXTRACTING MANGANESE NODULES FROM THE OCEAN FLOOR

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Abstract: This study has been undertaken to understand the feasibility of deep-seabed mining. The study reviews the advantages and challenges of extracting manganese nodules from the ocean floor under technical, ecological and economic considerations. Manganese deposits on the seabed contain large amount of other economically useful metals such as cobalt, nickel, copper, and zinc etc. Deep seabed mining is having a huge potential to satisfy the rising demand of metals in near future.

***IndexTerms* – Deep-Seabed Mining, Manganese Nodules.**

I. INTRODUCTION

Oceans occupy about 70% of the Earth's surface, but their depths are still largely unknown. There are abundant mineral deposits on the seabed that are arguably much richer than those found on land. These seabed resources can be used to create tools and emerging technologies, if extracted properly. Non-fuel minerals of both metallic and non-metallic forms are abound on the seabed. Manganese nodules, cobalt-rich manganese crusts, and polymetallic massive sulfides are examples of nonfuel mineral deposits that are of interest to the mineral industry.

The discovery of large deposits with high metal grades has sparked a lot of interest in deep-seabed mining. Many national and international research projects are currently attempting to comprehend the economical, environmental, social, and legal consequences of commercial deep-seabed mining operations. The International Seabed Authority (ISA) has the right to act on behalf of humanity to organize and control all mineral related activities and resources outside national jurisdiction.

Deep-seabed mining is the extraction of marine mineral resources such as manganese nodules, which include a variety of metals that are used as critical raw material in variety of applications, including mobile devices, clean energy technologies, and building materials. Manganese Nodules vary in size from few millimetres to massive pellets measuring more than 20 centimeters in diameter.

II. ADVANTAGE OF EXTRACTING MANGANESE NODULES FROM THE OCEAN FLOOR

In October 2017, the world's population was estimated to be around 7.6 billion people, and it is still growing [1]. More than 2.5 billion of them live in developing and middle-income countries. As a result, these individuals need to build the infrastructure and obtain the resources necessary to create a sustainable energy supply in the future. Deep-seabed mining can supply many of the rare metals needed for this expansion. The land-based resources of these rare metals are small. As a result, meeting population demand solely with land-based resources and maintaining sustainable growth is difficult [2, 3]. These manganese nodules have high concentration of Co, Ni, Cu, and Zn, making them a valuable financial reserve of these metals.

Attention to manganese nodules recovery is fueled by increasing demand and rising price of minerals and resources, as well as the volatility of land-based mineral supplies also plays a major role. According to a conservative estimate for the Clarion-Clipperton Zone (CCZ), there is around 21,100 million dry metric tonnes of nodules in the region. This will produce nearly 6,000 million tonnes of manganese, which is more than the entire land-based manganese reserve [4]. Similarly, the amount of nickel and cobalt will be two and three times higher than the total amount of nickel and cobalt in land-based reserves, respectively. The amount of copper in the Clarion-Clipperton Zone (CCZ) alone is roughly 20% of the world's land-based copper reserves [4].

To minimize emission, renewable energy and green technology have been built over time. Once their applications are firmly commercialized, both industries will eventually create massive additional demand for certain type of minerals [5]. To meet the demand in future, we must focus on deep-seabed mining as an alternative to land-based mineral resources. Mineral extraction technology, engineering, and machinery have advanced significantly, largely due to the oil, gas, dredging, and telecommunications industries. Most of these advancements can be used to extract deep-seabed minerals, bringing deep-seabed mining closer to commercialization. If technological challenges are resolved, it is projected that the only Europe's annual revenue from marine minerals mining will increase from zero to ten billion Euros by 2030 [6].

Manganese nodules recovery from the deep-seabed usually requires less mining, resulting in less direct and indirect impact on bottom-dwelling population. The abyssal seafloor has relatively low abundance of life [7]. In case of land mining, each activity usually leaves significant footprints both during and after the mining process. This is because there is a need to remove significant amount of overburden, under which resources are being locked. Manganese nodules mining will have smaller footprints since nodules are either lying on the seafloor or buried by just few centimeters of sediments. The open mining approach on land, which involves activities such as deforestation, disrupts the local ecology of the mined region. Birds and other animals need to find new habitats, and due to the large footprints left behind by the operation, it is doubtful that birds and other animals will be able to return to the mined region again. Deep-seabed mining, on the other hand, would have an effect on sparsely populated environment near the seafloor, where photosynthesis is hampered by lack of sunlight. There will be some impact on the habitats of local organisms that can live without sunshine, such as benthos. However, as compared to land mining, the impact is significantly smaller. While deep-sea mining undoubtedly has environmental consequences, it can still prove to be a better alternative to terrestrial mining if environmental regulations are implemented effectively and efficiently. In a study, researchers compared terrestrial mining to deep-seabed mining. Research findings clearly state that deep-sea mining appears to be a more attractive alternative to terrestrial mining [8].

Land mining is normally done for a single mineral, such as coal, gold, nickel, and so on. Deep-seabed mining of manganese nodules deposit, on the other hand, can provide a variety of minerals. Each land mine necessitates the construction of permanent infrastructure such as roads and towers. Deep-seabed mining is different since it is operated from the ocean surface through movable floating ships or barges. All of the equipments can be quickly relocated and deployed to another location once a plot of the seabed has been mined. As a result, less permanent infrastructure is needed. Deep-sea mining can be comparable to or less expensive than land mining in terms of long term capital costs.

For both economic and geopolitical reasons, sea-floor mining may give several states and companies a viable alternative to ensure future resource supplies. It will assist many countries with limited resource supplies in being less reliant on exporting countries. The ISA, in particular, guarantees that potential gains from deep-sea mining operations will be distributed fairly. The aim is to avoid a situation where only wealthy countries will have access to promising resources. It will assist many countries in achieving financial stability and resuming their path to development and prosperity.

III. CHALLENGES OF EXTRACTING MANAGENESE NODULES FROM THE OCEAN FLOOR

While deep-seabed mining is presented as an endeavor, it is important to remember that each resource present its own set of challenges. Environmental unknowns, vulnerabilities, and costs are considered to be among the most significant challenges associated with deep-seabed mining [9]. Due to the remoteness of the deep sea, as well as the harsh operating conditions (high pressure, low temperatures, and darkness), which necessitate costly and highly specialized equipments, much of the exploration and scientific study have been restricted so far [10].

The machines, involve in manganese nodules mining from the deep-seabed, must be able to handle extreme pressures at high water depths. Furthermore, equipments must be able to operate consistently for long periods, as deep-sea equipment maintenance is extremely costly. The supply of power to the machines at high depth is another problem. Even if high voltage connections are used, losses due to joule effect must be taken into account since long cabling is needed. Another factor to consider in determining the economic feasibility of exploiting deep-seabed manganese nodules deposits is fuel consumption. Even if mining is possible, the minerals must be shipped thousands of miles to be sold in the market, and the mother ship must be refueled regularly. Therefore, Building commercially viable machines is necessary to commercialize deep-seabed mining.

Since there is no visibility of the environment in the deep sea, control of the machines depends on auxiliary equipments (sensors, GPS, radar, etc). These equipments must be designed to operate over a broad spatial spectrum. The efficiency and costs of the nodule recovery process are heavily influenced by the seabed topography, which must be constantly monitored and overcome with the help of sophisticated machinery and mining techniques.

Also, Salinity and acidity of the seawater must be considered for feasible mining operations. This is a harsh area for metal parts to operate in, so routine maintenance and the use of special alloyed steel should be considered to avoid oxidation and mechanical failure of machines. Furthermore, the temperature gradient's non-uniformity must be addressed to resolve fatigue issues and define optimum operating temperature for the various components of the device.

Sediment plumes will be produced by nodules recovery vehicles as a result of mining [11, 12, 13]. The discharge plumes are likely to affect ocean-floor ecosystem. Deep seabed mining may result in biodiversity loss and forced species migrations [14]. This puts genetic material that can be used for biotechnical or medicinal purposes in the future at risk [15]. Deep-seabed mining activities in one jurisdiction can have negative consequences for the marine environment or coastal communities in another [16]. State should take necessary steps to maintain control over any seabed mining operation that falls under its jurisdiction. State laws governing seabed mining management should be "no less efficient" [17] than international rules, regulations, and procedures. Several countries that are actively involved in the exploration do not have a comprehensive legal framework in place yet (for example, India, France, South Korea, Brazil, Russia, and Poland) [18, 19].

Tourism contributes to a country's overall growth and development by providing various economic benefits and values. In places like Papua New Guinea, Fiji, Portugal, and Spain [9], loss of tourism is feared as a result of the threats from seabed mining operations. Deep-seabed mining may result in the loss of cultural or spiritual significance associated with the pristine ocean, as well as a traditional sense of ownership or association with the ocean and its resources [20].

IV. Conclusion

Deep-seabed mining of manganese nodules has the potential to benefit all of the mankind, but we have to approach it with care and adaptability to mitigate harm to ecosystem. Natural and social scientists, as well as economists, legal experts, and engineers, need to work together to integrate the perspectives of various disciplines early in the planning, discovery, and extraction phase to effectively tackle the highly complicated process of deep-seabed mining of manganese nodules. Proper planning and management will ensure long-term sustainability that will benefit both humanity and ecosystem. To efficiently carry out mining of manganese nodules, interdisciplinary analysis, mining tests, and simulations, as well as comprehensive environmental studies, are needed. The recovery of manganese nodules from the seabed will become more feasible in the future as technology advances and people gain a better understanding of and respect for the marine environment.

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