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Examining the benefits and the legal challenges of asteroid mining in outer space

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Abstract
Humanity has always been drawn to exploring new areas, mostly for the purpose of scientific and commercial advancement. This quest for new frontiers is inherent to the species. It has been suggested that asteroid mining may be used to supplement Earth-based rare earth metal supplies and provide resources, such water, to space. But as awareness of Earth's finite natural resources has grown, so has the emphasis on finding other celestial bodies that may be mined for additional purposes. By telescopic research and the analysis of meteorite fragments discovered on Earth, scientists have been able to learn more about asteroids. Asteroids are rocky objects that circle the sun. They range in size from a few meters across to the largest, Ceres, which is known as a "dwarf planet" because of its average diameter of 952 km. Located in the "main asteroid belt" between the orbits of Mars and Jupiter, the majority of the solar systems millions of asteroids are found. Countries where mining in space is an interest. With appropriate technology and regulations, mankind can use the abundant mineral resources on the moon and asteroids. Regarding legislation, the United States of America and Luxembourg have been the two countries that have specifically expressed interest in space mining. Regretfully, in the international law community, the legal concerns pertaining to mining asteroids in space have been a hot topic of conversation. The paper expands the benefits of asteroid mining and ponders on the global governance challenges brought about by space mining activities and suggests legal, policy and global frameworks.

Keywords: Space mining, asteroid, outer space treaty, moon agreement, global governance, International law

Introduction

It has often been suggested that mining asteroids, and especially mining Near Earth Asteroids (NEAs), might provide resources for both space and terrestrial applications [1]. The first close-up images of an asteroid were sent to the National Aeronautics and Space Administration (NASA) in 1991 by the Galileo mission, which was traveling to Jupiter.

On 433 Eros, in 2001, NEAR Shoemaker, the first asteroid probe, touched down (Bhalla, 2015) [31]. As space agencies continue to explore asteroids, the private sector may be able to take advantage of these opportunities to exploit natural resources. This could involve developing technologies to land on asteroids and identify near-Earth objects as well as verifying their composition in situ. This would push space commerce beyond low Earth orbit and into deep space (Mane, 2022) [32].

Several space faring nations such as USA, Luxemburg, A number of nations, including China and India, have indicated interest in space mining. (Ursul & Ursul, 2019) [35]. However, what legal implications result from mining asteroids in space? There have been frequent discussions on the legal ramifications of outer space mining activities and the absence of a regulatory framework, despite the fact that international space law has not changed significantly since the 20th century. Therefore, even though space mining is of interest, a legal analysis must be done. Countries would be encouraged to participate even though space mining operations would not begin for years if the legal context was clear.

Why asteroid mininng

One approach that has been suggested for mining elements that are often obtained via conventional mining as it now exists is asteroid mining. Not just in the broader space community but also in the more specialized field of space law, which is defined as "every legal or regulatory regime having a significant impact, even if implicitly or indirectly, on at least one type of space activity or major space application," asteroid mining is one of the hottest topics of discussion right now [2].

Eight private businesses, including Planetary Resources, are doing research into the viability of human and robotic missions to asteroids in addition to governmental organizations like NASA and JAXA (Japan Aerospace Exploration Agency) [3].

Consequently, obtaining materials that are essential for basic Earth subsistence is the primary goal of asteroid mining activities. Eight percent of metal-rich (M type) and seventy-five percent of volatile-rich carbonaceous (C type) asteroids have been found to be present in our solar system's asteroid belt [4].

Transporting raw materials and valuable minerals to Earth to replenish its rapidly running out resources is the second reason why heavenly mining corporations operate. This would have a big impact on the world economy and raise the mining company's valuation dramatically. In a 2012 interview with Reuters, Planetary Resources stated that platinum with a value ranging from US$25 billion to US$50 billion might be found on an asteroid measuring 30 meters (98 feet) in length [5].

Thirdly, countries such as India and China are looking to mine the Moon for extracting Helium-3, which is considered a clean and efficient form of energy. It is thought that this isotope could provide safer nuclear energy in a fusion reactor, since it is not radioactive and would not produce dangerous waste products.

Fourth, because iron, nickel, and cobalt are abundant on asteroids, humanity may be able to make tools in space [6]. The CEO of Planetary Resources, Chris Lewicki, stated that material can be taken from asteroids and used to 3D print objects that don't need to be launched on rockets. Then, it would be possible to construct tools, machinery, and even homes off Earth, which would further lower the expense of exploration.

Fifth, a lot of Middle Eastern countries are starting to prioritize resource extraction. The oil-producing Middle Eastern nations, like Saudi Arabia and the United Arab Emirates, are making significant investments in this sector as they consider using space travel as a means of diversifying away from the planet-wide advantages of fossil fuels. 2012 saw the announcement of the existence and desire to mine asteroids by two U.S.-based firms, Planetary Resources, Inc. ("Planetary Resources") and Deep Space Industries, Inc. ("Deep Space Industries").

Research methodology

This study will be methodically carried out by examining the benefits of asteroid mining and the current legal framework in international space law concerning mining in outer space. A review of the literature will be conducted in order to determine the legal concerns pertaining to the potential space mining sector. The approach of the USA in relation to asteroid and space mining will be discussed. To determine the gap in the international space law system addressing space mining activities, a critical examination will be conducted. Articles, books, conference documents were used in the article.

The benefits of asteroid mining

Mankind has long been developing instruments and equipment to enable it to stay in outer space. It is therefore only a matter of time before we begin to exploit the full potential of outer space and import the extracted minerals to Earth [7]. The United States' Federal Aviation Administration has already authorized the first private lunar mission in 2016.

Aside from developing technologies to land on asteroids, the space agencies' asteroidal exploration programs may pave the way for the private sector to exploit natural resources. This could include identifying near-Earth asteroids and verifying in situ their composition, which would enable the commercialization of space to move beyond low Earth orbit and into deep space. Additionally, asteroid mining technology may have a direct effect on the ecosystem (Mane, 2022) [32]

Before the 19th century, space exploration and utilization were only dreams. However, with the launch of satellites, moon missions, and other spacecraft, as well as the observation of far-off planets, the idea was realized thanks to the quick development of technology. An analogy would be that while it was not feasible in the past, several countries are hoping to harvest minerals in space in the near future. Many countries are currently thinking about mining in space due to the depletion of earth's mineral resources and the discovery of different metals and minerals on the moon and asteroids.

The asteroids are classified into three types (Chondrite, Stony and Metallic) where a 10 metre stony asteroid could provide with 6,50,000 kg of metals including gold and platinum and a Chondrite asteroid could provide with abundant water and organic compounds such as carbon, phosphorus etc.

Hydrogen and oxygen can be extracted from asteroidal water and utilized for a variety of applications, including refueling rockets and serving as a survival resource. Asteroids could be worth anything from a few billion to over a trillion dollars, depending on the size, composition, and value of the metals they contain [8]. It is useful for protecting astronauts and spacecraft from radiation. Its availability in orbit would allow for the carrying of greater mission-related cargo by significantly lowering the fuel component of the gross weight at launch (Bhalla, 2015) [31] If profitably mined, the asteroids may yield an abundance of valuable minerals that could alleviate concerns about the Earth's resource depletion. This is particularly true for the group of rare metals known as platinum and other elements that are scarce on Earth but abundant on some asteroids.

It is crucial to examine the legal framework surrounding space mining because the United States and Luxembourg have authorized and legalized space mining, as well as the ownership of resources mined, in their respective domestic laws passed in 2015 and 2017, and other countries, including China and Russia, have expressed interest in the practice (Ursul & Ursul, 2019) [35]

The international legal issues for asteroid mining

The majority of the legal basis for space operations comes from international treaties, which constitute international law. The aims and domestic policy objectives of the various spacefaring states are made clear by executive orders and other laws that support these accords.

The outer space treaty

The international community generally accepts the 1967 Outer Space Treaty. Numerous clauses in the agreement are regarded as customary international law, which means that all countries are subject to them rather than just the parties to the agreement. The idea of commercially exploiting the resources of celestial bodies is essentially absent from the Outer Space Treaty since the states that negotiated it in the late 1960s did not take it seriously.

Although most experts would agree that the reference to the freedom of use in Article I would cover commercial exploitation, the term "commercial exploitation" is not even included in the treaty [9]. The Outer Space Treaty is a multilateral international treaty written to establish common ground among nations engaging in space related activities, to protect and delineate space as the "common interest of all mankind," and to promote the "use of outer space for peaceful purposes" [10].

The most significant clause in Article II is that it is forbidden for a country to appropriate celestial bodies by sovereignty or any other method [11]. All states are free to access space as long as they abide by any other applicable principles of international law, and this paragraph has often been interpreted as creating a "global commons" that is not subject to the legal authority or jurisdiction of any one state. In Article III, the signatory nations agree to "carry on activities in the exploration and use of outer space. in the interest of maintaining international peace and security and promoting international co-operation and understanding" [12].

The parties to this agreement consent to abstain from building military installations, bases, and fortifications;

testing armaments; and carrying out military operations on celestial bodies [13]. to consider each astronaut as A "envoy of mankind," helping, rescuing, and bringing them back to their original conditions as needed. Parties are accountable for their own conduct in space and maintain control over state-registered items that are sent into orbit.

Stated differently, it means that no colonization in the legal sense is allowed; that is, no one is allowed to exercise total and exclusive jurisdiction over a territory and to exercise territorial sovereignty over it as if it were an outlying portion of the motherland. The key query here is what it implies for the issuance of mining rights: to whom and under what circumstances is it permissible? Second, according to Article I, research and usage must be done for the good of humankind [14]. The issue at hand is how, in light of potential mining operations, the benefit to humanity must be understood. Must the profits be divided among all? Should the extracted materials be sold on a global scale? Is the meaning limited to ensuring that no state shall experience any negative effects from mining operations? Whichever way, the res communis omnium theory has an impact on both. Free and unrestricted access to all celestial bodies, as well as international collaboration, are encouraged under the Outer Space Treaty. (Thibault, 2024) [34]

What rights operators have over areas surrounding installations or in places where activities are continuing, such mining, is not specified in the Outer Space Treaty. Numerous authors, both American and Soviet, assert that facility operators are entitled to a "safety zone" or "keep-out zone" around their facilities. Certainly states have a right to prevent damage or destruction of a facility by exerting a measure of control over activities within a reasonable distance around the facility [15].

In order to prevent interference with activities, the Outer Space Treaty and ordinary international law principles forbid it. Therefore, the exercise of authority in mining regions would also be justified to the extent required. It's unknown how big these safety or keep-out zones are physically, but if the similar system for drilling platforms on the continental shelf—which has 500-meter safety zones—is any guide, then one could predict that the extent of these zones will be strictly limited.

a. The moon agreement

Regarding the Moon Agreement, this seemed to be the future, therefore it was partially intended to handle potential commercial exploitation as well. Although the original wording was developed in agreement with key spacefaring nations, including the United States, it is nevertheless interesting to briefly address it here, even though it was never approved by them. The 1979 Moon Treaty declares that space resources are "the Common Heritage of Mankind" and specifically prohibits any form of property rights with respect to those resources. Other provisions would establish a significant bureaucracy to control development. Vague terms in the treaty also require "equitable sharing of benefits" with non-space-faring nations, which is interpreted to include both profit sharing and technology transfer (Wayne White & Associate Campus Counsel, 1991) [37]

Although the Moon Agreement has relatively little formal significance, it does present some intriguing points to think about when determining the proper international legal framework for space mining.

First, a specific regime that deviates from the Moon Agreement may be devised in principle under Article 1(1). This may include using the idea of the shared heritage of mankind [16]. This clause permits the development of an international regime that specifically addresses asteroid mining, even insofar as the Moon Agreement parties and proponents of the common heritage of mankind concept are concerned, if doing so would be deemed more beneficial and feasible than the initial application of the concept within the framework of the Law of the Sea. Secondly, it is noteworthy that the Moon Agreement specifically states that "extraterrestrial materials which reach the surface of the earth by natural means" are not included in its purview [17].

Though it is clear that resources mined by corporations do not naturally occur on Earth, it is important to highlight the distinction already drawn between materials from space and those from other planets. The space mining businesses would probably target asteroids that are smaller in size than the celestial entities that are often covered under that category, such the Moon and planets. Landing on an asteroid, which might go far closer to obtaining alien elements, would be a very different endeavor than landing on a celestial body.

Third, while it does not explicitly state or validate this, the concept of the shared legacy of humanity may indicate certain required benefit and technology sharing in accordance with the Law of the Sea and the Moon Agreement. The Outer Space Treaty, which states that "neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity, or of any natural person," builds on the treaty's general prohibition of national application" [18]. The addition of "in place" suggests that once extracted, such resources could by contrast legitimately become the property of, for instance, private operators.

b. Executive order 13914

"[U]ncertainty regarding the right to recover and use space resources" is acknowledged by Executive Order 13914, along with the deterring effect that ambiguity has had on the commercial industry. In an effort to allay any doubts, it goes on to acknowledge the Moon Treaty's considerations and the United States' non-signature. It states that "the United States does not view [outer space] as a global commons" and that "Americans should have the right to engage in commercial exploration, recovery, and use of resources in outer space, consistent with applicable law."

Because Section 2 of the Executive Order reiterates that the United States is not a party to the Moon Treaty (though the Executive Order refers to it as the Moon Agreement), that the United States does not consider it effective or necessary to guide nations, and that the Moon Treaty is not an expression of "customary international law," it is likely that the Outer Space Treaty is the primary reference point when it is mentioned in relation to applicable law.

c. The space acts

The U.S. Commercial Space Launch Competitiveness Act serves as the foundation for Executive Order 13914 [19]. It

was implemented five years earlier. The Competitive Space Launch Act specifies how the United States licenses and approves the use of space resources in accordance with the Outer Space Treaty and gives the government a legal framework for allowing domestic commercial firms to extract and use resources in space. Participants in space flights are indemnified under Title 1, "Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015" (SPACE Act) [20]. flexibility in obtaining launch licenses, and recommends “an authorization and supervision approach that would. promote the U.S. commercial space.

As long as space resources are mined on a first-come, first-served basis for disputes arising within U.S. jurisdiction and in declared compliance "with the international obligations of the United States," it acknowledges the property rights of American residents and businesses over those resources [21]. Stated differently, no U.S. court would acknowledge claims—especially those made by parties outside of the country—that said extracted space resources would be considered the proceeds of illicit activity or that they would need to be shared globally in accordance with a potential interpretation of the common heritage of mankind principle. Second, in accordance with the obligation placed on the United States by Article VI of the Outer Space Treaty to authorize and continuously supervise such activities, it calls for future regulation to authorize and supervise in further detail any operator interested in engaging in asteroid mining and potentially benefiting from the legitimacy of ownership rights.

Third, it calls upon the U.S. President to promote the interests of U.S. industry in the global context. Effectively, this means by way of some sort of international regime sympathetic to the interests of the United States and its companies. The market for space resources would by all accounts be global in nature; recognition of legitimate ownership rights of companies over celestial resources in the United States would not necessarily be accepted in other countries where an interest in such resources might otherwise exist (Von Der Dunk, 2018) [36]

However, Article I of the General Agreement on Tariffs and Trade may raise the defense that other states could not challenge the legitimacy of the United States' ability to enjoy free trade benefits as a “like product” if, for example, platinum mined on a celestial body were brought back to Earth in accordance with US legal regime [22].

Suggestions for international governance and mining laws development in outer space

One area of international agreement has emerged despite ongoing national debates over the rights of owners and miners in space: a legal framework for the exploration and extraction of these resources must be established in order to preserve space exploration for peaceful purposes and prevent an uncontrolled "free for all" in space [23]. Nonetheless, governments and academics cannot agree on the best course of action for creating this new legal framework [24].

a. The U.N. multilateral treaty

Process On the other end of the spectrum are those countries and organizations advocating for a new multilateral treaty, formed through the United Nations’ formal treaty-making process [25]. The Canadian Outer Space Institute urged COPUOS in an open letter dated August 2020 to start the official treaty-making process so that participating countries may begin negotiating a multilateral agreement on the exploration and use of space resources [26]. Asserting that such approaches "risk the development of separate, possibly inconsistent, governance frameworks, while marginalizing input from developing and non-spacefaring States," the letter voiced concern about the national and bilateral approaches adopted by nations like the United States.

The letter also made analogies between Antarctica, the deep seabed, and the high seas, all of which are "governed [by] specific, multilateral agreements" formulated by the UN, and outer space. More than 140 international scientists, lawmakers, and diplomats signed the letter. The multilateral treaty strategy is still supported by experts, even though Canada has signed the Artemis Accords since then. Ninety-five member states make up COPUOS, and the group meets once a year to examine issues regarding past, present, and future space activity. "General exchange of views on potential legal models for activities in exploration, exploitation and utilization of space resources" has been an item on the COPUOS agenda since 2016.

The last meeting of the Legal Subcommittee in 2019 focused heavily on revisiting the Moon Agreement, which no major spacefaring power has ratified to date.

Many factors make the multilateral treaty-making process attractive: a new international treaty created by COPUOS "would have widespread legitimacy," offer definite, legally-binding guidelines for the extraction of space resources, and be open to and accessible by all 95 member countries. The official treaty-making process does have some advantages, but they are outweighed by a number of drawbacks, most notably the protracted and difficult procedure needed for members to negotiate, reach a consensus, and sign and ratify the treaty.

b. An implementation plan for the moon agreement

An implementation strategy for the Moon Agreement is a less common way to address the legal ambiguity around space resources [27]. As was previously indicated, the 1979 pact is largely considered to be incomplete and faulty, and no significant space power has ever ratified it. This opinion is supported, among other things, by Article 11's requirement for an implementation agreement—which was never made—to establish a legal framework for the commercial use of space resources on the moon. Since the Moon Agreement expressly forbids the seizure of resources on the moon, the viability of commercial activity is highly dubious in the absence of this framework. A Model Implementation Agreement for the Moon Agreement has been released by The Space Treaty Institute, an academic institution that is "dedicated to peace and sustainability in outer space" and offers an alternative to the Artemis Accords.

Based on four organizational principles, the Model Implementation Agreement proposes to "[t]rade private property rights for public policy obligations," which would allow any location on the moon to be used for any purpose as long as parties adhere to the public policy obligations outlined in the Moon Agreement. These obligations include environmental protection, the preservation of areas of "special scientific interest," and permitting "free access to all areas" by other parties. By completing the gaps left by Article 11, the Model Implementation Agreement is meant to be enacted in tandem with the Moon Agreement and urge nations to join onto the Moon Agreement.

c. The development of private law in space

Another, more radical legal paradigm put out by some academics calls for creating a body of private law to regulate the extraction of space resources [28]. A set of regulations based on mutually agreed upon practices rather than sovereign authority, according to the model's proponents, "can lay the foundations for future space activities, without sparking a governmental scramble to project power" [29]. The idea is that private governance will eliminate the suspicion of political motivations, which has led nations like China and Russia to reject the US current approach, and prevent disputes that may come from "jurisdictional claim-staking" in space.

Some academics have drawn comparisons between the commercial space and international commerce, noting that the former is controlled by a private legal system that upholds its own principles, while the latter is settled in private through the assistance of global arbitration associations like the International Chamber of Commerce. When this approach is applied to space, academics predict that private organizations would be able to uphold property rights over space resources without acknowledgment from sovereigns, with governments acting as regulators [30].

d. The artemis accords: The U.S. approach

On May 15, 2020, NASA presented the Artemis Accords—the set of principles via which the United States aims to lead the creation of international law on space exploration and resource extraction by entering into bilateral agreements with other states. The Artemis Accords aim to urge other countries to take part in the Artemis Program and future space resource activities, as well as to encourage "the international community to reach a consensus on the legality of space resource [extraction]."

The objective stated in Executive Order 13914 is to "negotiate joint statements and bilateral and multilateral arrangements with foreign states regarding safe and sustainable operations for the public and private recovery and use of space resources" and "encourage international support for the public and private recovery and use of resources in outer space," which includes the creation of the Artemis Program and the Artemis Accords. The Artemis Accords have drawn criticism from other countries due to its bilateral nature, as each signatory will be obligated to a separate agreement with the United States.

Conclusion

The outer-space consists of vast amount of resources that can produce unimaginable benefits economically as well as environmentally. Today, fundamental Earth resources are almost exhausted, and pollution, conflicts, and diseases are consequences of their over-exploitation. The US Space Act provisions, at the moment, don't seem in line with the OST obligations. However, a breach of international law by the US cannot be claimed until a private US company commits a concrete action of appropriation without equitable distribution of its benefit on the ground of the US Space Act.

Currently, the international legal uncertainty regarding the proper and generally accepted regime applicable to asteroid mining remains unresolved. The world needs to find a valid alternative to such depletion, and outer space seems to offer it. Therefore, building an international legal framework in line with international space law principles is fundamental to guaranteeing an equitable distribution of such resources for the benefit of all humankind.

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