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# A MULTILATERAL REGIME FOR SPACE RESOURCE EXPLORATION AND UTILIZATION

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## Abstract

*The launched of Sputnik marked the beginning of space race. Since then state always tries to develop its technology to conquer outer space, including its natural resources. Outer Space Treaty and Moon Agreement affirm that outer space as the common heritage of mankind. Therefore, any states can not claim sovereignty over the territory nor natural resources. Yet, in 2015 the United States passed the Space Resource Exploration and Utilization Act which authorize its private entities to exploit and entitles them with series of rights, including the right of ownership over space resource. Thus, this paper examines the concept of the “common heritage of mankind” (“CHM”) in the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) and elaborates on the possibility of a multilateral regime for space resource exploration and utilization. Part 2 discusses the concept of the CHM and its application; it then followed by an in-depth analysis of the future multilateral regime in Part 3. Part 4 concludes that a multilateral regime, instead of a unilateral regime, shall be in the best position to balance the needs for space resource exploration and the interests of developing countries.*

**Keywords** : space resources, right of ownership, private entities, space exploration and exploitation

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## I. INTRODUCTION

Great achievements in space exploration and utilization have been made in the past 60 years since the successful launch of the first manmade satellite, Sputnik-1, on 4 October 1957.<sup>1</sup> With the rapid development of space science and technology, the exploration and utilization of space resources<sup>2</sup> is no more an illusion. Outer space has rich natural resources, which can bring great economic interests to human beings.<sup>3</sup> The international society was able to reach consensus on an international regime for the orderly development of space activities in the first two decades of the space age, however, it proves difficult to come to the common ground regarding the legal nature of and the attribution of the right over space resources once the exploration and utilization of

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<sup>1</sup> Karl Tate, “Sputnik: How the World’s 1<sup>st</sup> Artificial Satellite Worked (Infographic),” Space.com, accessed 3 October 2012, <https://www.space.com/17888-first-satellite-sputnik-1-explained-infographic.html>.

<sup>2</sup> unless otherwise stated, the term “space resources” in this Article refers to the natural resources in the outer space (including the moon and other Celestial bodies).

<sup>3</sup> See Ricky J. Lee, “Creating an International Regime for Property Rights under the Moon Agreement”, *Proceedings of the Colloquium on the Law of Outer Space* 42, (1999): 409.

space resources becomes a reality. While the exploration and use of outer space is defined to be “the province of all mankind” in the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty),<sup>4</sup> no rules are currently in place regarding the commercial exploitation of space resources, which is detrimental to the orderly development of space resource exploration and utilization.

Against this background, the United States (US) took the initiative to enact the “Space Resource Exploration and Utilization Act” (“the Act”) on 25 November 2015, serving to clarify the legal regime for commercial aspects of space resources at the domestic level. The Act not only encourages and provides legal protection for private entities (including the individuals) with the status of “United States citizen” to engage in the exploration and utilization of space resources but also entitles these private entities with a series of rights, including the right of ownership, over space resource derived from space exploration activities.

This unilateral action raised controversy among the international community. The International Institute of Space Law (IISL) took quick action by issuing a Position Paper on Space Resource Mining on 20 December 2015. At the same time, acknowledging that the Act to pay respect to the international legal obligations of the US, the Position Paper leaves it open as to whether the current legal situation is satisfactory.

As a consequence, the unilateral approach taken by the United States by issuing such Act, which is against the fact that the international community has not yet reached a consensus on the problems of the legal character of and the attribution of the right over space resources, will harm the national economic and security interests of relevant States, which are also engaged in the exploration and utilization of space resources.<sup>5</sup>

This paper examines the concept of the “common heritage of mankind” (“CHM”) in the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) and elaborates on the possibility of a multilateral regime for space resource exploration and utilization. Part 2 discusses the concept of the CHM and its application, to be followed by an in-depth analysis of the future multilateral regime in Part 3. Part 4 concludes that a multilateral regime, instead of a unilateral regime, shall be in the best

<sup>4</sup> Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 610 U.N.T.S. 205 (Entered into Force 10 October 1967) [Outer Space Treaty], art. 1.

<sup>5</sup> See Guoyu Wang, Yangzi Tao, “Analysis and Corresponding Suggestion on the ‘2015 Space Resource Exploration and Utilization Act’ of the United States”<sup>12</sup>, *Aerospace China*, (2015): 21.

position to balance the needs for space resource exploration and the interests of developing countries.

## II. COMMON HERITAGE OF MANKIND

In 1967, the concept of “CHM” was proposed by Malta’s Ambassador Arvid Pardo.<sup>6</sup> The term CHM refers to particular objects with special legal status.<sup>7</sup> Over the last 50 years, however, there has never been an official definition of this term and its substance has remained uncertain and controversial.<sup>8</sup> Most studies to date have focused on the content of the CHM principle rather than the definition thereof.<sup>9</sup> It should be noted that there is a difference between the meaning of the CHM and the CHM principle. While the former refers to particular objects in international law, the latter stands for the principle concerning how to utilize such objects. Therefore, the research on the content of the CHM principle cannot comprehensively and thoroughly reflect the content of the CHM. Commentators tend to elaborate the content of the CHM principle by classifying essential elements or core principles<sup>10</sup>. For example, Noyes points out that the CHM principle normally includes these following elements: the prohibition of any claim to sovereignty, vesting of the

<sup>6</sup> United Nations General Assembly, Resolution 2340 (XXII): Examination of the question of the reservation for exclusively peaceful purposes of the sea-bed and the ocean floor, and the subsoil thereof, underlying the high seas beyond the limits of present national jurisdiction, and the use of their resources in the interests of mankind (18 December 1967), at art 3

<sup>7</sup> See, eg, United Nations Convention on the Law of the Sea, opened for signature 10 December 1982, 1833 U.N.T.S. 397 (entered into force 1 November 1994) [UNCLOS], art.136; See, eg, Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, opened for signature 10 December 1982, 1363 U.N.T.S. 3 (entered into force 11 July 1984) [Moon Agreement], art 11(1).

<sup>8</sup> See, eg, Fritz, Jan-Stefan, “Deep Sea Anarchy: Mining at the Frontiers of International Law,” *International Journal of Marine and Coastal Law* 30 (2015): 445-476; Edwin Egede, “The Common Heritage of Mankind and the Sub-Saharan African Native Land Tenure System: A Clash of Cultures in the Interpretation of Concepts in International Law,” *Journal of African Law* 58 (2014): 71.

<sup>9</sup> See, eg.; Aline Jaeckela, Kristina M. Gjerdeb, Jeff A. Ardron, “Conserving the common heritage of humankind – Options for the deep-seabed mining regime,” *Marine Policy* 78 (2017): 150-157; Erik Franckx, “The International Seabed Authority and the Common Heritage of Mankind: The Need for States to Establish the Outer Limits of their Continental Shelf,” *Journal of Marine and Coastal Law* 25 (2010): 543-567; Carol R. Buxton, “Property in Outer Space: The Common Heritage of Mankind Principle vs. the First in Time, First in Right,” *Journal of Air Law and Commerce* 69, (2004): 691-693; Bradley Larschan, Bonnie C Brennan, Common Heritage of Mankind Principle in International Law, *Columbia Journal of Transnational Law* 21 (1983), Vol. 21, pp.305-306.

<sup>10</sup> See, eg, Kudirat Magaji W. Owolabi, “The Principle of the Common Heritage of Mankind,” *Nnamdi Azikiwe University Journal of International Law and Jurisprudence* 14 (2013): 52; Jennifer Frakes, “The Common Heritage of Mankind Principle and Deep Seabed, Outer Space, and Antarctica: Will Developed and Developing Nations Reach a Compromise,” *Wisconsin International Law Journal* 21 (2003): 411-415; Rana and Harminderpal Singh, “The Common Heritage of Mankind &(and) the Final Frontier: A Reevaluation of Values Constituting the International Legal Regime for Outer Space Activities,” *Rutgers Law Journal* 26: (1994): 229-230; Goedhuis, “Some Recent Trends in the Interpretation and the Implementation of the Rules of International Space Law,” *Columbia Journal of Transnational Law* 19 (1981): 219.

rights over space resources on mankind as a whole, reservation for peaceful purposes, protection of the environment, equitable sharing of benefits, and common management regime.<sup>11</sup> The above elements serve as the guiding rules for the use of space resources. However, these elements are not very useful in determining the legal status and characteristics of the CHM. Even worse, there is no consensus on the application of these elements,<sup>12</sup> and thus it should not be taken for granted that these elements serve as the sole basis for the understanding of the CHM.<sup>13</sup>

### III. A MULTILATERAL REGIME

Although the private entities' right of ownership over space resources is not expressly forbidden. But, it is totally unreasonable, unfeasible and even unnecessary to entitle the private entities the right of ownership, neither from the legal aspect nor from the emotional aspect. Because such action could violate the principle of non-appropriation and the essence of balancing interests of private entities derived from the exploration and utilization of space resources. Nevertheless, it will also jeopardize the notion of common interests of the whole international community.

Therefore, although the "Space Resource Exploration and Utilization Act" is not directly violating international law obligation. However, the problem lies in its provision, which entitles private entities to obtain the right of ownership over space resources. Therefore, it will lead to a negative impact on the existing legal regime of outer space law and will probably cause damage to the international legal order, and peace and security of outer space.

The reason is, on the one hand, with the significant development and rapid progress of science and technology, other countries will be compelled to engage in the exploration and utilization of space resources one day in the future. Meanwhile, on the other hand, it is crucial to preserve the common interests of the international community as a whole, and maintain the international legal order, and peace and security of outer space at the same time.

On the international law level, under the condition of conforming with the legal character of and the attribution of the right over space resources, while respecting the existing legal regime of the outer space law, the international society should promote the establishment of an international mechanism gov-

<sup>11</sup> John E. Noyes, "The Common Heritage of Mankind: Past, Present, and Future," *Denver Journal of International Law and Policy* 40, (2012): 456

<sup>12</sup> *Id.*, at 454.

<sup>13</sup> C.R. Buxton, "Property in Outer Space: The Common Heritage of Mankind Principle vs. the "First in Time, First in Right" Rule," *Journal of Air Law & Commerce* 69 (2004): p. 699.

erning the exploration and utilization of space resources.

## A. GUIDING PRINCIPLES FOR AN INTERNATIONAL REGIME

### 1. The Basic Principle Of Non-Appropriation

The non-appropriation principle is provided in the Outer Space Treaty that “[O]uter space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”<sup>14</sup> It has been considered to be part of customary international law. Space resources should not be appropriated definitely and absolutely. Article 6.2 of the Moon Agreement provides that samples of space resources may be collected and removed by States, and such samples will remain at the disposal of these States and may be used for scientific purposes. As a result, the Moon Agreement has shown its attitude towards the attribution of the right of appropriation over space resources used for scientific purposes. Therefore, States which collected space resources and removed them from outer space shall enjoy the right of appropriation.<sup>15</sup>

However, Article 6.2 of the Moon Agreement only grants States the right to use and the right of disposal over samples of space resources used for scientific purposes.<sup>16</sup> Both rights enjoyed by States are non-exclusive since Article 6.2 further requires that States should make a portion of samples available to other interested States for scientific investigation.<sup>17</sup>

In practice, space resources samples are ‘appropriated’ by an individual State. However, the quantity of samples is so tiny that such a circumstance may not even be regarded as appropriating the corresponding space resources.<sup>18</sup> The practice of individual States for appropriating space resources samples is thus far from constituting a rule of customary international law on the right of appropriation over space resources for scientific purposes.<sup>19</sup> Even if being used for scientific purposes, space resources may not be appropriated

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<sup>14</sup> Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, opened for signature 27 January 2007, 610 U.N.T.S. 205 (Entered into Force 10 October 1967) [Outer Space Treaty], art. II

<sup>15</sup> Zhenjun Zhang, Research on the International Legal Regime Governing the Exploration of the Lunar Resources 83 (2012).

<sup>16</sup> L. Tennen, *Outer Space: A Preserve for All Humankind*, Houston Journal International Law 2, (1979-1980): 156

<sup>17</sup> Fabio Tronchetti, *The Exploration Of Natural Resources Of The Moon And Other Celestial Bodies: A Proposal For A Legal Regime* (Leiden: Brill Nijhoff, 2009), 43.

<sup>18</sup> L. Tennen, *Towards a New Regime for Exploration of Outer Space Mineral Resources*, Nebraska Law Review 88, (2010): 812.

<sup>19</sup> *Id.*

yet.

Also, space resources may not be appropriated in situ of outer space, while those which have already been collected and removed should be excluded from the applicable scope of the 'non-appropriation' principle.<sup>20</sup>

The commercial value of space resources can only be realized after they are collected and removed from outer space for scientific or commercial use.<sup>21</sup> With the development of space science and technology, more and more space resources will be gradually collected and removed. States and private entities will naturally compete for the ownership of those space resources.

Consequently, if collected and removed space resources are excluded from the scope of non-appropriation, it will lead to the 'competition' of collecting, removing, and even appropriating space resources. Such a competition will inevitably lead to a negative impact on the international order of exploration and utilization of space resources. Even worse, the 'non-appropriation' principle would lose its practical meaning in the end, because, in the future, all the space resources will doom to be collected and removed, and then appropriated by States or private entities.<sup>22</sup> Therefore, the 'non-appropriation' principle shall apply to space resources that have been collected and removed from outer space.

## **2. "Free But Limited" Mechanism For The Exploration And Utilization Of Space Resources**

Free exploration and utilization of space resources should be upheld in accordance with the Outer Space Treaty, which encourages States and private entities to continue their efforts in the exploration and utilization of space resources and the maximization of the value of space resources.<sup>23</sup> However, such freedom should not be unlimited. The international community should restrict the means, degree, and scope of the exploration and utilization, and the attribution of the profits derived from the exploration and utilization to a certain extent.

Article 11.5 of the Moon Agreement provides that the international community should establish an international regime to govern the exploration and utilization when these activities become feasible. It is necessary to start considering possible limits for the means, degree, and scope of the exploration

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<sup>20</sup> Shouping Li, *The New Development of Space Activities in 21<sup>st</sup> Century and Its Legal Regimes* 93 (2016).

<sup>21</sup> *Ibid.*

<sup>22</sup> Tennen, *Towards a New Regime*, 796.

<sup>23</sup> LM. Fountain, "Creating Momentum in Space: Ending the Paralysis Produced by the "Common Heritage of Mankind" Doctrine," *Connecticut Law Review* 35, (2003): 1753-1787.

and utilization.<sup>24</sup>

Currently, only a few States and private entities have grasped space technologies for the exploration and utilization of space resources. Unlimited freedom in the exploration and utilization of space resources will inevitably lead to substantive unfairness, thereby causing damage to the interests of States which are yet to have necessary space technologies as such.<sup>25</sup>

There are divergent views in the academic field concerning the attribution of profits derived from the exploration and utilization of space resources. Some scholars argue that all the interests/profits derived from the exploration and utilization should be shared by all mankind,<sup>26</sup> while others maintain that States and private entities should have the exclusive rights over the interests/profits (material achievements) from these space activities.<sup>27</sup>

Such distinct views demonstrate two different positions concerning the priority between the common interests of the whole international community and the due interests of States and private entities.

The attribution of the interests/profits derived from the exploration and utilization should be fair and balanced. While taking into account the common interests of the whole international community, the attribution should put proper emphasis on the protection of the due interests of States and private entities.<sup>28</sup>

## B. PROCEDURAL ASPECTS OF AN INTERNATIONAL REGIME

Considering the existing international regime in other fields of international law, such as the International Seabed Authority under the UNCLOS,<sup>29</sup> it would be possible to establish an “International Space Authority” to play the role of an international mechanism, to specifically govern the exploration and utilization of space resources.<sup>30</sup>

<sup>24</sup> D. O’Donnell & P. Harris, “Legal Strategies for a Lunar Economic Development Authority”, *Annals Air and Space Law* 21, (1996): 121-133.

<sup>25</sup> Yin, Yuhai. and Mingyue Wang, “A Concept Study of “Common Inherited Property of Mankind” in Outer Space Law,” *Journal of Beijing University of Aeronautics and Astronautics (Social Science Edition)* 24, (2011).

<sup>26</sup> L. Tennen, *Outer Space: A Preserve for All Humankind*, 2 *Houston Journal of International Law* (2), (1979-1980).

<sup>27</sup> Shouping Li, *The New Development of Space Activities in 21<sup>st</sup> Century and Its Legal Regimes* 93 (2016).

<sup>28</sup> John S. Lewis and Christopher F. Lewis, “A Proposed International Legal Regime for the Era of Private Commercial Utilization of Space,” *The George Washington International Law Review* 37 (2005)

<sup>29</sup> Zhao Yun, “Legality of Unilateral Exploration of Space Resources under International Law.” *International & Comparative Law Quarterly* 66, (2017): 991

<sup>30</sup> C. Christol, “An International Regime, Including Appropriate Procedures, for the Moon: Article 11, Paragraph 5 of the 1979 Moon Treaty for the Moon,” *Proceeding on Law of Outer Space* 23, (1980)



In order to establish such an international regime, both space-faring nations and non-space-faring nations need to reach a consensus on all the key aspects.<sup>31</sup> Although it would take a long time, such an Authority will have significance. In this regard, one or more of the space-faring nations are expected to play a leading role in establishing the Authority. It will not only help these States significantly promote their discourse power over space affairs, but also provide an advantageous international platform for relevant States to effectively respond to the unilateral approach of appropriating space resources, such as the Act.<sup>32</sup> Such an Authority will provide the best platform for States and private entities to negotiate the details of such a regime and to distribute the profits derived from the exploration and utilization.<sup>33</sup> For a proper and effective function, the proposed Authority should have its specific purposes, functions, and decision-making system.

### 1. The Purposes

Freedom of space exploration should be upheld, subject to some reasonable limits. The proposed International Space Authority should in the first place ensure the exercise of such a freedom, with explicit provisions on possible limits.<sup>34</sup> Otherwise, excessive intervention or even strict control by the Authority in the exploration and utilization will lead to market distortion and dampen the enthusiasm of exploring and utilizing space resources from private entities.<sup>35</sup>

It is thus suggested that the restrictions to free exploration and utilization of space resources should only be set based on the ‘non-appropriation’ principle (non-appropriation of space resources) and the protection of common interests of all mankind.

Moreover, closely related to the free exploration and utilization, the free-market approach should also be adopted for issues such as the sharing of space technologies and profits from the exploration. The proposed Authority should not force States or private entities to transfer space technologies and share the profits from space exploration for free or on a certain rate.<sup>36</sup> Instead, they

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<sup>31</sup> E. Paxson, “Sharing the Benefits of Outer Space Exploration: Space Law and Economic Development” *Michigan Journal of International Law* 14 (1992-1993): 509.

<sup>32</sup> Guoyu Wang and Yangzi Tao, “Analysis and Corresponding Suggestion on the “2015 Space Resource Exploration and Utilization Act” of the United States,” *Aerospace China* 12, (2015): 24-25.

<sup>33</sup> Christol, An International Regime, Including Appropriate Procedures, for the Moon: Article 11, Paragraph 5 of the 1979 Moon Treaty for the Moon.

<sup>34</sup> R. Berkley, “Space Law Versus Space Utilization: The Inhibition of Private Industry in Outer Space”, *Wisconsin International Law Journal* 15, (1996):421-444.

<sup>35</sup> *Id.*, at 437.

<sup>36</sup> R. Hoover, “Law and Security in Outer Space from the Viewpoint of Private Industry,” *Journal of Space Law* 11, (1983): 115.

should be free to decide whether to transfer certain technologies or share a certain portion of profits, as long as it does not violate the unfair competition rules or the 'non-appropriation' principle. Furthermore, the transfer of space technologies should be negotiated on an equal basis, and the rates are set at a reasonable and fair market level in return.<sup>37</sup>

Such an arrangement can provide sufficient protection to the interests of the States and private entities that ensure to continue their venture in outer space. Moreover, it will also help to preserve the common interests of the whole international community by obtaining necessary space technologies on a market rate and benefitting on an economic term from relevant space explorations.

## 2. The Functions

To achieve those purposes, the International Space Authority should take up the following two basic functions. one is registration and publication. The relevant States and private entities shall report their space exploration activities to the Authority, which shall register such activities and publicize them to the international community. The content of such registration and publication should include relevant space technologies, the target celestial bodies, and resources, and the interests/profits to be derived from the exploration and utilization.<sup>38</sup> The registration and publication services shall help to create a transparent regime for space exploration and utilization, avoiding unhealthy competition among the States and private entities. Once registered, relevant States and private entities shall have the priority in conducting the activities in the target celestial bodies and resources.<sup>39</sup> The information maintained with the Authority shall also help States and private entities interested in relevant space technologies to locate relevant parties for communication and negotiation.<sup>40</sup>

The other is fees levied and management. The proposed Authority, on behalf of the international community, should levy fees on States and private entities involved in the exploration and utilization of space resources. The levy rate is decided following the elements such as the investment made by relevant States and private entities for the exploration and utilization; the environmental conditions which might be affected by such activities; and the economic situations of other States that may be affected by the exploratory ac-

<sup>37</sup> Yun, "Legality of Unilateral Exploration," 289.

<sup>38</sup> John S. Lewis and Christopher F. Lewis, "A Proposed International Legal Regime for the Era of Private Commercial Utilization of Space," *The George Washington International Law Review* 37, (2005)

<sup>39</sup> P. Nesgos, *The Proposed International Sea-Bed Authority as a Model for the Future Outer Space International Regime*, 5 *Annals Air & Space L* 5, (1980):557

<sup>40</sup> Yun, "Legality of Unilateral Exploration," 289-290.

tivities.<sup>41</sup> The levied fees are offered by the Authority to give the right to space exploration and utilization. The Authority shall make use of such fees on behalf of the international community in an equitable manner. Consequently, the levy can supposedly be leverage to strike a balance between the protection of the interests of the States and private entities involved in the space activities and the realization of common interests of the international community.<sup>42</sup>

As mentioned above, the proposed regime is essential to ensure that there is no violation of the ‘non-appropriation’ principle and that the international community as a whole can benefit from space activities.<sup>43</sup> Moreover, the Authority should make sure that relevant States and private entities comply with other basic principles of space law, including the principle of peaceful uses of outer space. For example, relevant space activities should be solely for peaceful purpose and should not lead to harmful contamination or adverse changes to the environment. In case of violations against the above principles, the Authority is suggested to bring relevant cases to the International Court of Justice (“ICJ”).

#### IV. CONCLUSION

It is argued that the CHM can be defined as an exclusive property of mankind under the UNCLOS. Under the exclusive property model, mankind, as a separate entity, can have ownership over the CHM, while other entities can only exercise usufruct to the CHM. The three characteristics of the CHM and the three stages of the utilization system are in line with UNCLOS’ provision and derived from the exclusive ownership of mankind.

With the above model already in practice for the deep sea-bed resources, it is further argued that this model can be extended to other types of CHM, in particular, the CHM in outer space as defined in the Moon Agreement. Relevant modifications to the rules and procedures may be needed to accommodate different features of the CHM in various fields.

The exclusive property model as argued in this paper provides a new perspective on commercial use of the CHM in practice by answering the questions: what is the CHM? what can be considered as the CHM? and how to make use of the CHM?

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<sup>41</sup> *Id.*, 291-292.

<sup>42</sup> Jeremy L. Zell, “Putting a Mine on the Moon: Creating an International Authority to Regulate Mining Rights in Outer Space,” *Minnesota Journal of International Law* 15, (2006):489.

<sup>43</sup> Nesgos, “The Proposed International Sea-Bed Authority as a Model for the Future Outer Space International Regime”.

With a proper understanding of the CHM and a possible mechanism for commercial use of the CHM, we conclude that multilateral, instead of unilateral approach to revitalizing the CHM would best serve the interests of the international community. The unilateral act of making national legislation by the US has aroused heated discussions in the international society on the ideal regime for exploitation and utilization of natural resources in outer space.<sup>44</sup> The sleeping beauty of the CHM has been awakened; a multilateral approach can only justify its legal status and characteristics as argued in this paper by setting up an international regime for exploitation and utilization of natural resources of outer space.

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<sup>44</sup> Yun, "Legality of Unilateral Exploration,"991.

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