



School of Law
UNIVERSITY OF GEORGIA

Prepare.
Connect.
Lead.

Georgia Law Review

Volume 57 | Number 4

Article 8

7-12-2023

Property, Sovereignty, and Customary Governance in Outer Space Resource Extraction

Monika U. Ehrman

Follow this and additional works at: <https://digitalcommons.law.uga.edu/glr>



Part of the [Law Commons](#)

Recommended Citation

Ehrman, Monika U. (2023) "Property, Sovereignty, and Customary Governance in Outer Space Resource Extraction," *Georgia Law Review*: Vol. 57: No. 4, Article 8.

Available at: <https://digitalcommons.law.uga.edu/glr/vol57/iss4/8>

This Article is brought to you for free and open access by Digital Commons @ University of Georgia School of Law. It has been accepted for inclusion in Georgia Law Review by an authorized editor of Digital Commons @ University of Georgia School of Law. [Please share how you have benefited from this access](#) For more information, please contact tstriepe@uga.edu.

Property, Sovereignty, and Customary Governance in Outer Space Resource Extraction

Cover Page Footnote

Charles J. and Inez Wright Murray Distinguished Visiting Professor, SMU Dedman School of Law (joining as Professor of Law in Fall 2023). The author appreciates the thoughtful comments by Melissa J. Durkee and Rebecca Hamilton. And many thanks to the editors at the Georgia Law Review, especially Savannah Grant, Tripp Keeffe, and Millie Price for the opportunity to participate in the 2023 Symposium, as well as for the invitation to contribute to this issue of the Georgia Law Review. Thanks also to the SMU Underwood Law Library and Tom Kimbrough and Gregory Ivy for their research assistance.

PROPERTY, SOVEREIGNTY, AND CUSTOMARY GOVERNANCE IN OUTER SPACE RESOURCE EXTRACTION

*Monika U. Ehrman**

Space technology related to extraterrestrial resource extraction has exploded. The ability to extract frozen water from asteroids or mine the lunar surface for critical minerals and water-ice is nearly viable and the potential wealth is staggering. But herein lies one of the most complicated property ownership problems—who owns these natural resources? Ownership not only includes the right to take, but also the right to exclude. As scholars have often explained, the right to exclude is the centerpiece of property rights. However, who holds these rights? And, in fact, should anyone have these rights? Space is the ultimate Ostromian commons.

This Article discusses certain challenges related to outer space resource extraction and the assertion of property rights, particularly as they relate to sovereignty and customary governance. It first reviews the major governing outer space framework, which includes the outdated U.N. Outer Space Treaty, borne out of the aggressive space race during the Cold War. Like its natural resource relation, the U.S. 1872 General Mining Law, it has not changed since its inception. And just like in the early days of mining in the U.S., participants in outer space mining and outer space resource extraction are not waiting for resolution on ownership or utilization questions.

*Charles J. and Inez Wright Murray Distinguished Visiting Professor, SMU Dedman School of Law (joining as Professor of Law in Fall 2023). The author appreciates the thoughtful comments by Melissa J. Durkee and Rebecca Hamilton. And many thanks to the editors at the Georgia Law Review, especially Savannah Grant, Tripp Keeffe, and Millie Price for the opportunity to participate in the 2023 Symposium, as well as for the invitation to contribute to this issue of the Georgia Law Review. Thanks also to the SMU Underwood Law Library and Tom Kimbrough and Gregory Ivy for their research assistance.

1770 *GEORGIA LAW REVIEW* [Vol. 57:1769]

TABLE OF CONTENTS

I. INTRODUCTION	1771
II. A HISTORICAL REVIEW OF OUTER SPACE TREATY AND LAW	1777
A. THE ANTARCTICA ANALOG TO EXTRATERRESTRIAL EXPLOITATION.....	1778
B. THE SPACE ECONOMY	1783
III. SPACE MINING	1786
A. SPACE PROPERTY: ACCESS, OWNERSHIP, AND DEVELOPMENT	1788
IV. CONCLUSION.....	1795

I. INTRODUCTION

Under a butterscotch-colored sky, the Perseverance rover cautiously navigates over the rocky and dusty Martian terrain.¹ On a scientific mission to investigate the possibility of past life and future habitability, the Mini Cooper-sized robot dutifully negotiated a thirty-one-Martian-day journey to arrive at the Jezero Crater's ancient river delta.² NASA scientists identified the crater as an advantageous landing site, theorizing that liquid water had once carved channels in the rock and created a massive lake as the waters rushed over the crater's walls about 3.5 billion years ago.³ Astrobiologists hope that remnants of microbial life remain in the deltaic sediments; so using a small drill at the end of its robotic arm, Perseverance gathers rock cores and samples.⁴ NASA and the European Space Agency plan to collect these samples, analyzing the precious cargo for evidence of extraterrestrial life and knowledge of the geological processes that formed the crater billions of years ago.⁵

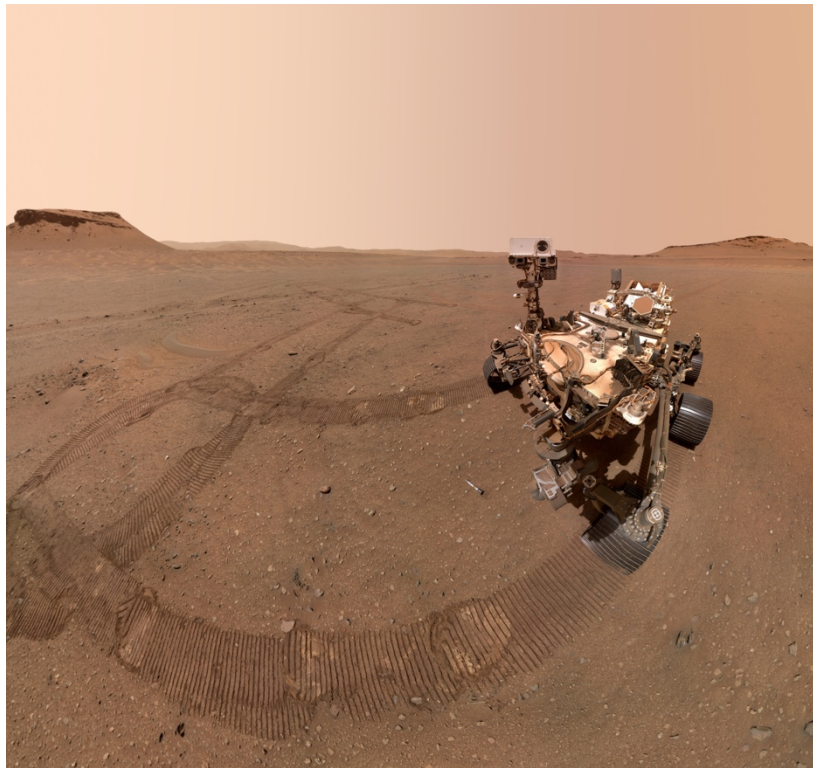
¹ See *Frequently Asked Questions*, NASA [hereinafter *Perseverance FAQ*], <https://mars.nasa.gov/mars2020/mission/faq/> (last visited Feb 13, 2023) (describing the Perseverance rover).

² *NASA's Perseverance Rover Arrives at Delta for New Science Campaign*, NASA (Apr. 19, 2022), <https://mars.nasa.gov/news/9170/nasas-perseverance-rover-arrives-at-delta-for-new-science-campaign>.

³ See *Perseverance Rover Landing Site: Jezero Crater*, NASA, <https://mars.nasa.gov/mars2020/mission/science/landing-site/> (last visited Feb 13, 2023) (telling a "story of the . . . wet past of mars" identified in Jezero Crater).

⁴ See *Perseverance FAQ*, *supra* note 1 ("The Perseverance rover pioneers a drill that can collect core samples of the most promising rocks and soils, and set them aside in a 'cache' on the surface of Mars.").

⁵ See Sarah Kuta, *Perseverance Rover Completes Depot of Mars Rock Samples*, SMITHSONIAN MAG. (Feb. 1 2023), <https://www.smithsonianmag.com/smart-news/perseverance-rover-completes-depot-of-mars-rock-samples-180981560/> (discussing the difficult "long chain of events" that must be overcome to recover the Mars samples).

Figure 1.0: Perseverance's Three Forks Sample Depot Selfie⁶

The ambitious Mars exploration missions, replete with selfie-taking, social media-savvy robots, thrill us with the wondrous feats of human endeavor despite the hefty price tag of \$2.7 billion.⁷ Unsurprisingly, NASA remains a popular agency with bipartisan support.⁸ After all, who wouldn't support the noble goal of scientific space exploration to further human knowledge?

⁶ See *Perseverance's Three Forks Sample Depot Selfie*, NASA (Jan. 24, 2023), <https://mars.nasa.gov/resources/27262/perseverance-three-forks-sample-depot-selfie/> (providing a selfie taken by the Perseverance rover with its sample collection tubes).

⁷ See *Cost of Perseverance*, PLANETARY SOC'Y, <https://www.planetary.org/space-policy/cost-of-perseverance> (last visited Feb 13, 2023) (noting that the Perseverance accounted for .0075% of all U.S. government spending between 2013 and 2020).

⁸ See Monika U. Ehrman, *Natural Resource Systems and the Evolution of Environmental Law*, 40 PACE ENV'T. L. REV. 495, 506 (2023) (pointing out that "Americans love NASA and space exploration"); see also Kaleigh Rogers & Zoha Qamar, *How Americans Feel About Space*,

But what is less discussed is that outer space exploration includes a central goal of commercial exploitation and private wealth accumulation.⁹ In 2017, investment bank Goldman Sachs advised its clients of a new space age that would generate a multitrillion dollar economy—an age of space mining.¹⁰ Its analyst wrote that “[they] believe space mining is still a long way from commercial viability, but it has the potential to further ease access to space and facilitate an in-space manufacturing economy. . . . Space mining could be more realistic than perceived . . . a single asteroid the size of a football field could contain \$25 billion to \$50

FIVETHIRTYEIGHT (July 15, 2022, 6:00 AM), <https://fivethirtyeight.com/features/one-of-the-few-things-americans-agree-on-space-is-cool/> (“It turns out, it is one of the few areas where Americans largely agree. In a July 2021 poll from YouGov/The Economist, a majority of Americans said the U.S. should send astronauts to the moon and Mars. This was true across political parties, with slim majorities for Democrats, Republicans and independents. Most Americans are also on the same page about funding space exploration. About a third of Democrats, Republicans and independents said government funding of space exploration should be kept the same, and about 40 percent of each group said funding should be increased. Find me another issue where roughly the same share of Republicans and Democrats agree that the government is not spending enough money.”).

⁹ This is not to exclude the ample discussion of significance of private sector activities in outer space in legal literature, specifically in student notes. See generally Amanda M. Leon, Note, *Mining for Meaning: An Examination of the Legality of Property Rights in Space Resources*, 104 VA. L. REV. 497, 497 (2018) (concluding that U.S. legislation “abrogates the United States’ international obligations . . . [and] fails to achieve its goal of providing the private space industry with the legal certainty it . . . requires”); Alison Morris, Note, *Intergalactic Property Law: A New Regime for a New Age*, 19 VAND. J. ENT. & TECH. L. 1085 (2017) (analyzing whether national regulation granting private companies property rights in outer space resources is consistent with the Outer Space Treaty); Stephen DiMaria, Note, *Starships and Enterprise: Private Spaceflight Companies’ Property Rights and the U.S. Commercial Space Launch Competitiveness Act*, 90 ST. JOHN’S L. REV. 415 (2016) (same); Thomas R. Irwin, Note, *Space Rocks: A Proposal to Govern the Development of Outer Space and Its Resources*, 76 OHIO ST. L.J. 217 (2015) (giving an overview of current law and proposing a new international treaty in this area); Austin C. Murnane, Note, *The Prospector’s Guide to the Galaxy*, 37 FORDHAM INT’L L.J. 235 (2013) (considering which, if any, national and international laws apply to outer space resources); Blake Gilson, Note, *Defending Your Client’s Property Rights in Space: A Practical Guide for the Lunar Litigator*, 80 FORDHAM L. REV. 1367 (2011) (analyzing the Outer Space Treaty interpretation in context of property law principles); Kelly M. Zullo, Note, *The Need to Clarify the Status of Property Rights in International Space Law*, 90 GEO. L.J. 2413 (2002) (discussing the Outer Space Treaty).

¹⁰ See Lauren Thomas, *In a New Space Age, Goldman Suggests Investors Make It Big in Asteroids*, CNBC (Apr. 6, 2017, 10:51 AM), <https://www.cnbc.com/2017/04/06/goldman-sachs-tells-investors-to-consider-new-space-age.html> (summarizing Goldman Sachs’ statement to its clients).

billion worth of platinum.”¹¹ In addition to the behemoths SpaceX, Blue Origin, and Virgin Galactic, other venture capital (VC) firms and private investors are betting on space investment, including Fidelity and the VC arm of Google.¹²

Private enterprise is not the only party interested in space mining and commercialization. In 2015, President Obama signed the world’s first national space resources law.¹³ The U.S. Commercial Space Launch Competitiveness Act of 2015¹⁴ (the Act) indicates an obvious focus within its very name—the words “exploration” and “cooperation” are absent, and “commercial” and “competitiveness” appear instead. The Act contains numerous provisions of interest, but its address of space resources is most significant. At the very end of the law, within Title IV “Space Resource Exploration and Utilization,” the Act defines ownership of asteroid and space resources.¹⁵ Pointedly, the terms are defined separately—an asteroid resource is not included within the term space resource.¹⁶ The Act provides that the President, acting via agencies, shall “promote the right of United States citizens to engage in commercial exploration for and commercial recovery of space resources free from harmful interference, in accordance with the international obligations of the United States and subject to authorization and continuing supervision by the Federal

¹¹ *Id.*

¹² *See id.* (discussing the current investment market in space related ventures); *see also* Melissa J. Durkee, *Interstitial Space Law*, 97 WASH. U. L. REV. 423, 426 (2019) (describing the author’s theory of attributed lawmaking, where private actor conduct “can contribute to the formation of uncodified international law—customary international law and treaty practice—when that private conduct is attributed or imputed to the state.”).

¹³ *See* Alex Gilbert, *Mining in Space Is Coming*, MILKEN INST. REV. 1, 10 (Apr. 26, 2021), <https://www.milkenreview.org/articles/mining-in-space-is-coming> (citing that “in 2015 Congress passed and President Obama signed the world’s first national space-resources law”). Other nations are also looking into space resources. *See* Richard B. Bilder, *A Legal Regime for the Mining of Helium-3 on the Moon: U.S. Policy Options*, 33 FORDHAM INT’L L.J. 243, 243, 246 (2010) (explaining that the major spacefaring nations other than the US—Russia, China, and India—are exploring whether they can mine and bring to Earth Helium-3).

¹⁴ U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 51303, 129 Stat. (2015).

¹⁵ *Id.* § 51301.

¹⁶ *See id.* (defining the different terms).

Government.”¹⁷ Citizens of the U.S. are granted additional authority over these extraterrestrial resources:

A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.¹⁸

From a property scholar perspective, possession; ownership; use; and sale are fundamental property rights, analogously represented as a “bundle of sticks.”¹⁹ Although those engaged in commercial enterprise may have a Congressional grant of ownership and related property interests in asteroid and space resources, the more important question is whether those property rights are themselves associated with sovereignty. Immediately following the ownership provision is essentially a legal disclaimer, which is titled “Disclaimer of Extraterritorial Sovereignty.” It proclaims that: “It is the *sense* of Congress that by the enactment of this Act, the United States does not thereby assert sovereignty or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body.”²⁰ Congress likely intended its disclaimer to protect public and private off-world resource extraction activities, believing that mining minerals and ice from space is not an act of territoriality. But even a well-intentioned belief would be incorrect—the assertion of ownership over extraterrestrial resources is, by that same exercise, an exertion of sovereignty.²¹

The Outer Space Treaty of 1967²² directly addresses sovereignty: “[O]uter space is not subject to national appropriation by claim of

¹⁷ *Id.* § 51302.

¹⁸ *Id.* § 51303.

¹⁹ See Kurt Anderson Baca, *Property Rights in Outer Space*, 58 J. AIR L. & COM. 1041, 1047–58 (1993) (discussing the role of property rights as they relate to outer space).

²⁰ U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 51303, 129 Stat. (2015) (emphasis added).

²¹ JULIE MICHELLE KLINGER, *RARE EARTH FRONTIERS* 224–25 (Cornell Univ. Press, 2017).

²² See Treaty on Principles Governing the Activities of States in Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410,

sovereignty, by means of use or occupation, or by any other means” and, to a lesser extent, “the Moon and other celestial bodies shall be used exclusively for peaceful purposes.”²³ While it permits all participants to use space resources, there cannot be interference with the activities of others. However, protection of property rights directly affects both the validity and valuation of property rights, which impacts commerciality.²⁴ The exclusionary right—or right to keep people away from one’s own property—is central to the concept of private property.²⁵ Moreover, property is valuable only if others

610 U.N.T.S. 205, art. 1–2 [hereinafter Outer Space Treaty] (outlining terms and opening the treaty for signature to the United States, United Kingdom, and Union of Soviet Socialist Republics). The treaty was also opened for signature by the United Kingdom and the Russian Federation. *Id.*

²³ *Id.* The Outer Space Treaty provides the basic framework on international space law, including the following principles:

The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind; outer space shall be free for exploration and use by all States; outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means; States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner; the Moon and other celestial bodies shall be used exclusively for peaceful purposes; astronauts shall be regarded as the envoys of mankind; States shall be responsible for national space activities whether carried out by governmental or non-governmental entities; States shall be liable for damage caused by their space objects; and States shall avoid harmful contamination of space and celestial bodies.

Id.; see also Dominic Basulto, *How Property Rights in Outer Space May Lead to a Scramble to Exploit the Moon’s Resources*, WASH. POST (Nov. 18, 2015, 7:09 AM), <https://www.washingtonpost.com/news/innovations/wp/2015/11/18/how-property-rights-in-outer-space-may-lead-to-a-scramble-to-exploit-the-moons-resources/> (“The Outer Space Treaty indirectly suggests that commercial space companies don’t own the rights to any resources they find in outer space. The treaty states that no ‘celestial body’ is subject to ‘national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.’”).

²⁴ See Henry R. Hertzfeld & Frans G. von der Dunk, *Bringing Space Law into the Commercial World: Property Rights Without Sovereignty*, 6 CHI. J. INT’L L. 81, 81 (2005) (setting forth the argument that a lack of exclusionary rights or private property regime in space can deter commercial investments).

²⁵ See, e.g., Zachos A. Paliouras, *The Non-Appropriation Principle: The Grundnorm of International Space Law*, 27 LEIDEN J. INT’L L. 37, 50 (2014) (“[A]s a matter of international law, the appropriation of any part of outer space . . . by private individuals is precluded by

recognize it as property owned by another. Without this recognition and legal acknowledgment, disputes as to ownership and infringement are likely.

This Article provides a brief and broad overview of the relevant law and policy and questions the mechanics of a property system for outer space resources.²⁶

II. A HISTORICAL REVIEW OF OUTER SPACE TREATY AND LAW

Modeled after the Antarctic Treaty, the Outer Space Treaty was borne out of the geopolitical tensions of the Cold War²⁷ and the ensuing “Space Race” competition between the U.S. and the Soviet Union.²⁸ The competition was responsible for decades of rapid, technological space missions,²⁹ including the first human in space,

Article II of the Outer Space Treaty. Hence, any state that confers proprietary rights in outer space would commit an internationally wrongful act”); *Space Law*, 54 INT’L L. ASS’N REP. CONF. 405, 429 (1970) (“[T]he draftsmen . . . never intended this principle to be circumvented by allowing *private* entities to appropriate areas of the Moon and other celestial bodies.”); see generally Abigail D. Pershing, Note, *Interpreting the Outer Space Treaty’s Non-Appropriation Principle: Customary International Law from 1967 to Today*, 44 YALE J. INT’L L. 149, 154–57 (2019) (arguing through analysis that the non-appropriation principle was originally intended to be construed broadly and unambiguously); see also Erwan Beauvois & Guillaume Thirion, *Partial Ownership for Outer Space Resources*, 3 ADVANCE ASTRONAUTICS SCI. TECH. 29, 33–34 (2020) (proposing a theory of partial ownership of outer space resources, which allows open competition for resources—exclusion—without the granting of a monopoly).

²⁶ There are numerous research resources available in this area that are not discussed in this Article. For more information in this area of property and outer space, please refer to such sources as: R. VENKATA RAO, V. GOPALAKRISHNAN & KUMAR ABHIJEET, *RECENT DEVELOPMENTS IN SPACE LAW: OPPORTUNITIES & CHALLENGES* (2017) (providing ten scholarly articles relating to outer space laws); see also OUTER SPACE LAW: LEGAL POLICY AND PRACTICE, (Yanal Abul Failat & Anél Ferreira-Snyman eds., 2d ed. 2022); Jinyuan Su, *Legal Status of Abiotic Resources in Outer Space: Appropriability, Ownership, and Access*, 35 LEIDEN J. INT’L L. 825, 825 (2022) (addressing the legal status of abiotic resources in outer space).

²⁷ See Bailey DeSimone, *How the Antarctic Treaty of 1959 Influenced the Outer Space Treaty of 1967*, LIBR. CONG.: BLOGS (Jan. 28, 2022), <https://blogs.loc.gov/law/2022/01/how-the-antarctic-treaty-of-1959-influenced-the-outer-space-treaty-of-1967/> (“[T]he Antarctic Treaty and the Outer Space Treaty were both created during the Cold War and with the emergence of nuclear weapons being a particular concern.”).

²⁸ See *id.* (explaining that the “need for outer space law began in the late 1950s with the start of the ‘space race’ between the United States and the Soviet Union”).

²⁹ See Andrew S. Erickson, *Revisiting the U.S.-Soviet Space Race: Comparing Two Systems in Their Competition to Land a Man on the Moon*, 148 ACTA ASTRONAUTICA 377, 378 (2018)

Soviet cosmonaut Yuri Gagarin;³⁰ remote exploration on Venus and Mars;³¹ and, most notably, the Apollo 11 moon landing with U.S. astronauts Neil Armstrong and Buzz Aldrin walking on the lunar surface.³² Following these nascent decades of space advancement, exploration and scientific missions were primary goals of most national space agencies.

During the Cold War, however, the proliferation of nuclear weapons combined with the Soviet Union's launch of the Sputnik 1 satellite drove deep international security concerns of circumnavigating ballistic nuclear missiles.³³ To address those post-World War II security concerns, "[i]n 1958 and 1959, two international committees, the Committee on Space Research (COSPAR) and the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS), were formed to promote international cooperation in scientific research and encourage the peaceful use of outer space."³⁴ It was U.S. President Eisenhower who proposed using the then recent Antarctic Treaty of 1959 as a model for the Outer Space Treaty.³⁵ This southern polar area serves as a useful analog to extraterrestrial exploration and why governance and enforcement matter.

A. THE ANTARCTICA ANALOG TO EXTRATERRESTRIAL EXPLOITATION

In the 1950s, seven countries—Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom—made

(stating that Soviet Union and American space projects were representative of the "race for technological supremacy").

³⁰ See *id.* at 377–78 (explaining that "Moscow stepped up propaganda and programs" in the space race and that a resulting Soviet Union feat was when "Yuri Gagarin became the first human in orbit, further capturing the world's imagination").

³¹ See *id.* at 378 (suggesting that a renewed competition occurred when the Soviet Union "demonstrate[d] significant technical prowess by launching space stations and by sending scientific probes to Venus and Mars").

³² See *id.* (detailing the Soviet Union's efforts in the "moon race's final stage" to beat the Apollo 11 mission).

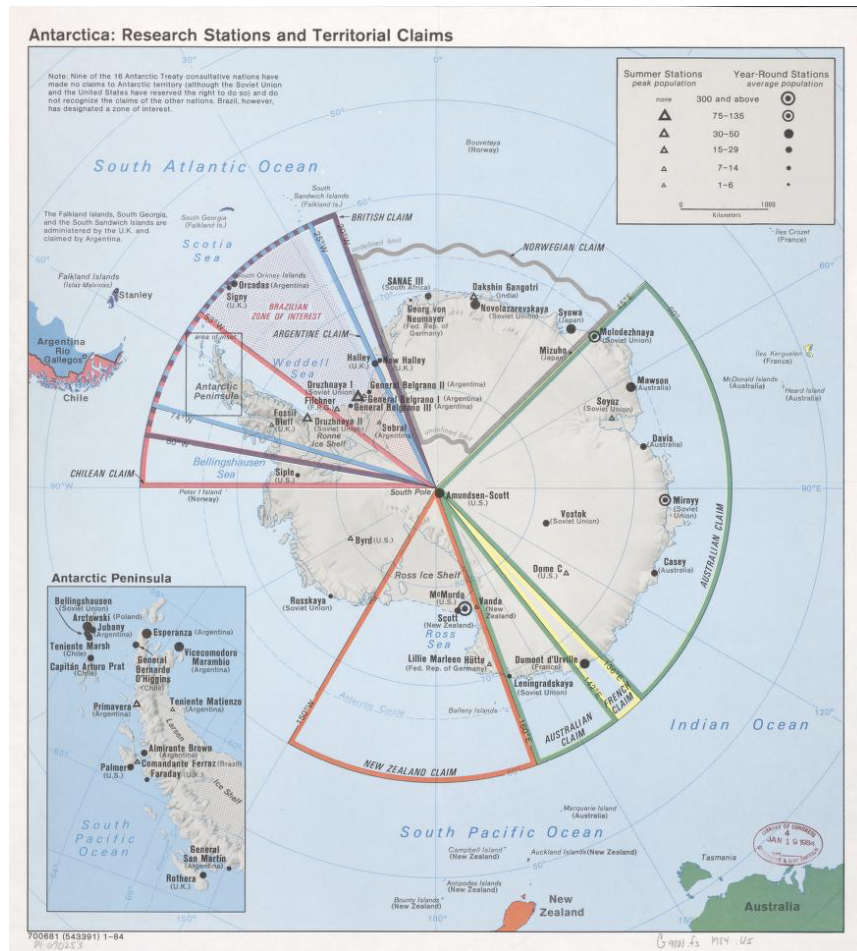
³³ See *id.* at 377 (explaining how Americans were alarmed by Sputnik's launch, which was cited as evidence of the Soviet Union passing the West in the space race, and how Russian leaders believed a "new era of missiles could 'demonstrate the advantages of socialism'").

³⁴ DeSimone, *supra* note 27.

³⁵ See *id.* ("President Eisenhower proposed that the principles of the Antarctic Treaty of 1959 be applied to outer space. . . .").

territorial claims to their Antarctic discoveries.³⁶ The overlapping nature of the claims resulted in conflict and led to the treaty's adoption.

Figure 2.0: Antarctica, Research Stations and Territorial claims³⁷



³⁶ Sophia Guido, *History of the Antarctic Treaty System*, LIBR. CONG., <https://www.loc.gov/ghe/cascade/index.html?appid=eb78cec7f5e34c40a2ee13732c4bf805&bookmark=Discovery> (last visited Feb 23, 2023). Other countries—the United States, the Soviet Union, Belgium, Japan, and South Africa—had also explored Antarctica but made no territorial claims. *Id.*

³⁷ *Antarctica, Research Stations and Territorial Claims*, LIBR. CONG., <https://www.loc.gov/item/84690253/> (last visited Mar. 6, 2023).

Signed in Washington, D.C., in 1959, the Antarctic Treaty³⁸ stated that international scientific research and cooperation in Antarctica should continue peacefully and prohibited all military activities, nuclear explosions, and radioactive waste disposal. The treaty also declared that no country could claim territorial sovereignty over any part of the continent.³⁹ The Antarctic Treaty has garnered great praise and success as a model of international cooperation. The British Antarctica Survey romanticizes the endeavor, declaring:

There are few places in the world where there has never been war, where the environment is fully protected, and where scientific research has priority. But there is a whole continent like this—it is the land the Antarctic Treaty parties call “. . . a natural reserve, devoted to peace and science.”⁴⁰

While this romanticism and international cooperative pride may indeed be well deserved, it must be noted that the 1959 Antarctic Treaty and the 1961 Outer Space Treaty are similar mainly because of their environments' perceived (lack of) value at the time of treaty negotiation and adoption.⁴¹ Each environment was extreme, remote, vast, relatively unknown, and had “*potentially* valuable resources.”⁴² Whales, fish, orbital space, and moon rocks were all fine—but these spaces were not seen as colonizable or economically exploitable. Therefore, at that time, it made sense for Eisenhower to propose using the same principles of the Antarctic Treaty for the Outer Space Treaty. However, as climate, technology, and market demand change, these two environments' resources may cause a

³⁸ The Antarctic Treaty, Dec. 1, 1959, 402 U.N.T.S. 71, art. 1.

³⁹ *Id.* art. IV(2).

⁴⁰ *The Antarctic Treaty Explained*, BRITISH ANTARCTIC SURV., <https://www.bas.ac.uk/about/antarctica/the-antarctic-treaty/the-antarctic-treaty-explained/> (last visited Feb. 23, 2023).

⁴¹ Regarding the Outer Space Treaty, Gabrynowicz observes “[t]he speed with which the international community established this treaty regime demonstrates a clear intent that space was to be governed by international law.” Joanne Irene Gabrynowicz, *One Half Century and Counting: The Evolution of U.S. National Space Law and Three Long-Term Emerging Issues*, 4 HARV. L. & POL'Y REV. 405, 422 (2010).

⁴² DeSimone, *supra* note 27 (emphasis added).

rush to exploit them, no matter the international governing agreement.

In Antarctica, economically impenetrable ice naturally guarded against commercial excursions. However, the increase in temperatures due to climate change has made what was previously hidden more visible and demonstrably valuable. Mining on the Southern Continent is banned under the Madrid Protocol, which is set to expire in 2048.⁴³ Arguably, there was not much interest in mining minerals or exploring for hydrocarbons due to the massive amount of ice overlaying any source rock; the extreme weather environments; and the exorbitant cost and risk required to transport the resources to a market.⁴⁴ Warmer weather is melting the Antarctic ice, which may lure modern prospectors and tech billionaires to explore and lobby governments to refuse renewals and extensions of bans, or even exit longstanding treaties. Off the western coast of Greenland, a “band of billionaires, including Jeff Bezos, Michael Bloomberg and Bill Gates,”⁴⁵ are funding exploration of critical minerals “below the surface of the hills and valleys on Greenland’s Disko Island and Nuussuaq Peninsula [predicting] there are enough critical minerals to power hundreds of millions of electric vehicles.”⁴⁶ The billionaire-backed mining company, Kobold Metals, is “looking for a deposit that will be the first-or second-largest most significant nickel and cobalt deposit in the world.”⁴⁷ These minerals will be used to develop climate friendly projects, such as electric vehicles and massive, commercial batteries to store renewable energy.⁴⁸

⁴³ *The Protocol on Environmental Protection to the Antarctic Treaty*, SECRETARIAT OF THE ANTARCTIC TREATY, <https://www.ats.aq/e/protocol.html> (last visited Feb. 24, 2023).

⁴⁴ *See generally Human Impacts on Antarctica and Threats to the Environment—Mining and Oil*, COOL ANTARCTICA, https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_mining_oil.php (last visited Feb. 23, 2023).

⁴⁵ René Marsh, *Billionaires Are Funding a Massive Treasure Hunt in Greenland as Ice Vanishes*, CTV NEWS (2022), <https://www.ctvnews.ca/climate-and-environment/billionaires-are-funding-a-massive-treasure-hunt-in-greenland-as-ice-vanishes-1.6019085> (last visited Feb. 23, 2023).

⁴⁶ *Id.*

⁴⁷ *Id.*

⁴⁸ *See id.* (explaining that rare and precious metals are essential to build electric vehicles and massive batteries).

The irony is unmistakable. Due to anthropogenic climate change, previously remote and economically inaccessible areas, rich in diverse ecological environments, are now open to extractive industries funded by private wealth to develop resources needed to combat said climate change. Industry is likewise aware:

“It is a concern to witness the consequences and impacts from the climate changes in Greenland,” Bluejay Mining CEO Bo Møller Stensgaard told CNN. “But, generally speaking, climate changes overall have made exploration and mining in Greenland easier and more accessible.” Stensgaard said that because climate change is making ice-free periods in the sea longer, teams are able to ship in heavy equipment and ship out metals out to the global market more easily. Melting land ice is exposing land that has been buried under ice for centuries to millennia—but could now become a potential site for mineral exploration. “As these trends continue well into the future, there is no question more land will become accessible and some of this land may carry the potential for mineral development,” Mike Sfraga, the chair of the United States Arctic Research Commission, told CNN.⁴⁹

What is happening in Greenland will happen in Antarctica. Although the continent’s mineral resources are yet unassessed, it is rich in a new resource—one that will also be central to space exploration—water.⁵⁰ Antarctic ice comprises about ninety percent of Earth’s total ice volume and seventy percent of planetary fresh water.⁵¹ As technology prowess increases and Antarctic climate

⁴⁹ *Id.*

⁵⁰ See *Water Production in Space: Thirsting for a Solution*, NASA (Oct. 21, 2015), https://www.nasa.gov/mission_pages/station/research/benefits/water_in_space/#:~:text=Developing%20and%20maintaining%20water%20production,a%20bit%20of%20a%20challenge (“Developing and maintaining water production on the International Space Station is vital for keeping the crew alive as well as supporting hygiene and equipment functions, yet it presents a bit of a challenge.”).

⁵¹ NAT’L SCI. FOUND., *THE UNITED STATES IN ANTARCTICA: REPORT OF THE U.S. ANTARCTIC PROGRAM EXTERNAL PANEL 9* (1997), <https://www.nsf.gov/pubs/1997/antpanel/antpan03.pdf>.

warms, the lure of extracting water for consumption and sale will exacerbate dormant territorial claims.⁵²

Like the California Gold Rush, where miners exploited and extracted minerals based on community custom in the relative absence of governing law,⁵³ the new resource miners are in pursuit of critical minerals and the fortune—and monopolistic power—that undoubtedly follow.⁵⁴ Their pursuit will lead them to remote expanses on Earth and in space.

B. THE SPACE ECONOMY

The “space economy” includes those “goods and services produced in space for use in space, such as mining the moon or asteroids for material.”⁵⁵ The Organisation for Economic Co-operation and Development defines it as any activity that involves “exploring, researching, understanding, managing, and utilizing space.”⁵⁶ Wienzierl and Sarang in the *Harvard Business Review* explains how the majority of revenue earned in the space sector was from the “space-for-earth” economy:

[T]hat differentiates this “space-for-space” economy with the “space-for-earth” economy, which includes goods or services produced in space for use on earth. The space-for-earth economy includes telecommunications and internet infrastructure, earth observation capabilities, national security satellites, and more. This

⁵² See J.L. HULT & N.C. OSTRANDER, ANTARCTIC ICEBERGS AS A GLOBAL FRESH WATER RESOURCE 23, R-1255-NSF (Oct. 1973), <https://www.rand.org/content/dam/rand/pubs/reports/2008/R1255.pdf> (discussing the societal and environment impacts of exploiting Antarctic ice and the need for a collection of rules to regulate this exploitation due to potential territorial claims).

⁵³ See generally Monika U. Ehrman, *Natural Resource Property Customs*, 41 UCLA J. ENV'T. L. & POL'Y (forthcoming 2023) (analyzing the origin of property customs in mining communities and the eventual legislation of the miners' customs in U.S. mining law and the prior appropriation doctrine in Western water law).

⁵⁴ See Marsh, *supra* note 45 (discussing how the melting of Greenland “is creating an opportunity for investors and mining companies who are searching for a trove of critical minerals capable of powering the green energy transition”).

⁵⁵ Stefan Ellerbeck, *The Space Economy Is Booming. What Benefits Can It Bring to Earth?*, WORLD ECON. F. (Oct. 19, 2022), <https://www.weforum.org/agenda/2022/10/space-economy-industry-benefits/>.

⁵⁶ *Id.*

economy is booming, and though research shows that it faces the challenges of overcrowding and monopolization that tend to arise whenever companies compete for a scarce natural resource, projections for its future are optimistic. Decreasing costs for launch and space hardware in general have enticed new entrants into this market, and companies in a variety of industries have already begun leveraging satellite technology and access to space to drive innovation and efficiency in their earthbound products and services.⁵⁷

Commercial cellular technology was in its infancy in the late 1970s and defense and militaristic initiatives focused on using orbital technology for Earth-bound uses.⁵⁸ The development of a reusable launch vehicle—NASA’s venerated space shuttle program⁵⁹—allowed bilateral movement to orbit and back. However, the cost of the shuttle program and the loss of astronauts on Space Shuttle Columbia’s 2003 mission⁶⁰ was a barrier to sustainable economic enterprise.⁶¹ Public-private space partnerships would remove that barrier—enter the tech billionaires.

⁵⁷ Matthew Weinzierl & Mehak Sarang, *The Commercial Space Age Is Here*, HARV. BUS. REV. (Feb. 2021), <https://hbr.org/2021/02/the-commercial-space-age-is-here>.

⁵⁸ See *id.* (“As far back as the 1970s, research commissioned by NASA predicted the rise of a space-based economy that would supply the demands of hundreds, thousands, even millions of humans living in space, dwarfing the space-for-earth economy (and, eventually, the entire terrestrial economy as well).”).

⁵⁹ See Ray A. Williamson, *Developing the Space Shuttle*, in EXPLORING THE UNKNOWN 161, 162 (1995) (discussing how far back the conceptual origins of the NASA Space Shuttle reached and how it began to explore the feasibility of an reusable launch vehicle (RLV) in space for a variety of military applications).

⁶⁰ See Rachel Treisman, *Twenty Years After the Columbia Disaster, a NASA Official Reflects on Lessons Learned*, NPR (Feb. 1, 2023), <https://www.npr.org/2023/02/01/1153150931/columbia-space-shuttle-disaster-20th-anniversary> (noting how on the morning of February 1, 2003, seven astronauts were killed on board the Space Shuttle Columbia).

⁶¹ See James Gerstenzang, *Bush Denounces NASA Fund Cuts: Space: The President Says Exploration Programs Cannot Wait Until All of the Nation’s Social Ills Are Solved. He Also Stumps for Helms in North Carolina*, L.A. TIMES (June 21, 1990), <https://www.latimes.com/archives/la-xpm-1990-06-21-mn-156-story.html> (discussing President Bush’s new push for space spending at a time of political pressures on whether America will continue to be a pioneering nation for space exploration).

Public-private partnerships are not new in near-Earth technology. Communications Satellite Corporation (COMSAT) and INTELSAT are now global telecommunications companies that began as NASA and government sponsored satellite projects.⁶² As former NASA deputy administrator Lori Garver explained:

These initially quasi-government organizations contributed to the evolution of a burgeoning, profitable telecommunications market that transformed society through instantaneous communications. Private entities incentivized by national governments and international organizations helped create the infrastructure that first allowed us to transmit signals, then voices, pictures, and video, and eventually the internet to anyone else on the planet, anywhere, in real time.⁶³

The invitation of private companies to design and develop cost-effective reusable launch technologies is likewise promoting global infrastructure to access outer space. Economic launch access provides the ability to send cargo, goods, and labor to space.⁶⁴ Competition between launch technology providers will likely drive down future costs, but only to a point. Although the launch vehicles are privately developed (possibly with public-private support), NASA provides the launch facilities, which limits open or equitable access. However, with the allowance of any access, market opportunities are soon to follow.⁶⁵

⁶² See LORI GARVER, *ESCAPING GRAVITY: MY QUEST TO TRANSFORM NASA AND LAUNCH A NEW SPACE AGE* 1, 167 (2022) (“The potential for communications satellites to deliver value beyond NASA and the government was recognized early, which led to their privatization through COMSAT and INTELSAT in the 1960s.”).

⁶³ *Id.*

⁶⁴ See *id.* at 25 (discussing Obama’s proposal to “shift NASA away from developing and owning systems for routine operation and incentivize the private sector to provide space transportation services for cargo and astronauts”).

⁶⁵ See, e.g., Paul Burka, *Texas Primer: The Farm-to-Market Road*, TEX. MONTHLY (Apr. 1983), <https://www.texasmonthly.com/being-texan/texas-primer-the-farm-to-market-road/> (discussing how the farm-to-market road is different as well as a symbol of culture in the state of Texas).

III. SPACE MINING

In the first minutes after the Big Bang, all the matter in our universe, that will ever exist, was created. The primordial elements hydrogen and helium were those most abundant and formed in the first seconds after the Big Bang.⁶⁶ Lithium, the next lightest element, also had a prodigious birth: “[s]cientists believe that 25 percent of the lithium was created in our universe’s infancy—before even most stars had formed.”⁶⁷ The majority of all the heavier elements were birthed in the “churning heat of stars.”⁶⁸ The Law of Conservation of Mass explains that mass is neither created nor destroyed in a chemical reaction,⁶⁹ which for space mining purposes means that minerals—particularly *economically recoverable* minerals—are in finite supply.

There is increased concern about critical mineral supply.⁷⁰ These critical minerals—not to be confused with being exclusively rare earth elements—constitute inputs for important technologies related to energy production, defense, pharmaceutical, and transportation technologies. The U.S. tracked these supply chains, many of which failed or were impacted during the exacerbated stress of the COVID-19 pandemic, learning that there was a high level of dependence on the import of minerals.⁷¹ The location of these minerals, many of which are in geopolitically unstable nations, like China and Russia, exposed the U.S. to supply chain failures and

⁶⁶ See NEIL DEGRASSE TYSON, *ASTROPHYSICS FOR PEOPLE IN A HURRY* (1st ed. 2017) (noting that ninety percent of the elements were hydrogen and ten percent were helium).

⁶⁷ See Danny Lewis, *Most Lithium in the Universe Is Forged in Exploding Stars*, SMITHSONIAN MAG. (Nov. 4, 2016), <https://www.smithsonianmag.com/smart-news/most-lithium-universe-forged-exploding-stars-180961009/> (explaining the Big Bang contributed a significant amount of the lithium in the world today).

⁶⁸ *Id.*

⁶⁹ Robert W. Sterner, Gaston E. Small & James M. Hood, *The Conservation of Mass*, NATURE EDUC. KNOWLEDGE (2011), <https://www.nature.com/scitable/knowledge/library/the-conservation-of-mass-17395478/>.

⁷⁰ See *The U.S. Is Worried About Shortages of Critical Minerals for Electric Vehicles, Military Tech*, PBS NEWSHOUR (Apr. 13, 2021, 5:14 PM), <https://www.pbs.org/newshour/nation/the-u-s-is-worried-about-shortages-of-critical-minerals-for-electric-vehicles-military-tech> (noting the U.S. governments’ worry about and investment in critical minerals).

⁷¹ *Id.*

national security risks.⁷² And unlike hydrocarbons, the U.S. has a low source of national, natural resource supply.⁷³ This lack of mineral resource supply and abundance of external risk exposure elevated the United States' response to secure critical mineral supply.⁷⁴ One such source lies in outer space—particularly on asteroids.

The cost to obtain the minerals is currently daunting, with estimates of off-planet mineral wealth in the billions and trillions of dollars. One current measure of potential value estimates that “mining just the top 10 most cost-effective asteroids—that is, those that are both closest to Earth and greatest in value—would produce a profit of around US\$1.5 trillion.”⁷⁵ Astrophysicist Neil DeGrasse Tyson famously predicted that the world's first trillionaire would be they who mined asteroids.⁷⁶ Space mining startups and venture capital firms are delighted to recount the positive and seemingly endless possibilities of space mining, foretelling a space economy filled with tourism and human settlement.⁷⁷ The view is not entirely optimistic though:

[M]any experts argue on the flip side that asteroid mining would quickly destroy the economy of global raw materials, currently valued at about US\$660 billion. They claim this economy would be quickly overtaken by the quintillions of dollars' worth of material from asteroid mining. Asteroid mining resources would flood the market, causing a rapid devaluation of global raw materials. Such a situation was simulated by researchers at Tel Aviv University. They predicted that a significant “global struggle for resources and power” would ensue in a world with asteroid mining. They came

⁷² See *id.* (highlighting the United States' reliance on instable nations for access to critical minerals and the national security issues that follow).

⁷³ See *id.* (“The United States' own mining and recycling of these [critical] minerals is still small.”).

⁷⁴ See *id.* (explaining that the U.S. has rethought strategy and invested in their continued access to critical minerals).

⁷⁵ Shriya Yarlagadda, *Economics of the Stars: The Future of Asteroid Mining and the Global Economy*, HARV. INT'L REV. (Apr. 8, 2022, 9:00 AM), <https://hir.harvard.edu/economics-of-the-stars/>.

⁷⁶ *Id.*

⁷⁷ *Id.*

to this conclusion after creating a simulation in which one shipment of space minerals devalued the price of gold on Earth by 50 percent.⁷⁸

The possibility of destabilizing, with or without intent, global commodity markets and political economies is a high probability.⁷⁹

A. SPACE PROPERTY: ACCESS, OWNERSHIP, AND DEVELOPMENT

Robust markets require certainty of ownership and security of title: resource supply alone is inadequate. In the U.S., the major governing treaties, laws, and policies over extraterrestrial mineral ownership are: the Outer Space Treaty of 1967; various U.S. domestic space law and policy, which governs operations and activities of U.S. citizens and U.S. entities in space; and the more recent Artemis Accords.⁸⁰ Domestic law and policy also includes the Act, which permits U.S. citizens to “possess, own, transport, use, and sell” asteroid and space resources.⁸¹

In 2020, President Trump furthered the Obama Administration legislative stance that U.S. citizens could own extraplanetary resources by issuing an executive order *Encouraging International Support for the Recovery and Use of Space Resources*.⁸² President Trump noted that (i) “[s]uccessful long-term exploration and

⁷⁸ *Id.*

⁷⁹ *See id.* (explaining how the raw material market could be impacted by asteroid mining) Yarlagadda further suggests a real possibility of this struggle is that “developing countries would be significantly affected because they heavily rely on mineral exports and do not have the resources to build their own asteroid mining operations.” *Id.* Specifically, “research efforts underway to determine the amount of other elements, including cobalt, on different asteroids” put “a wide variety of fledgling economies . . . at risk. For example, the possibility of obtaining cobalt from asteroids could wreck the Democratic Republic of the Congo’s cobalt mining operations. This would ultimately damage the nation’s entire economy.” *Id.*

⁸⁰ There are various other non-binding treaties and agreements on the use of space, in addition to the Artemis Accords, which are not discussed here. *See generally* Outer Space Treaty, *supra* note 22 (outlining the foundational principles of international space law and the exploration of space); *see also* NASA, THE ARTEMIS ACCORDS: PRINCIPLES FOR COOPERATION IN THE CIVIL EXPLORATION AND USE OF THE MOON, MARS, COMETS, AND ASTEROIDS FOR PEACEFUL PURPOSES (2020) [hereinafter ARTEMIS ACCORDS] (containing thirteen provisions related to international collaboration on space exploration projects).

⁸¹ U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, 129 Stat. 704 (2015).

⁸² *See* Exec. Order No. 13914, 85 Fed. Reg. 20,381 (Apr. 6, 2020) (explaining the United States’ approach to the recovery of space resources).

scientific discovery of the Moon, Mars, and other celestial bodies will require partnership with commercial entities to recover and use resources, including water and certain minerals, in outer space” and (ii) there was “[u]ncertainty regarding the right to recover and use space resources, including the extension of the right to commercial recovery and use of lunar resources, however, [which] has discouraged some commercial entities from participating in this enterprise.”⁸³ With those explanations, the order declared that:

Americans should have the right to engage in commercial exploration, recovery, and use of resources in outer space, consistent with applicable law. Outer space is a legally and physically unique domain of human activity, and *the United States does not view it as a global commons*. Accordingly, it shall be the policy of the United States to encourage international support for the public and private recovery and use of resources in outer space, consistent with applicable law.⁸⁴

Commons literature and references to the commons are most familiar in economics and law scholarship.⁸⁵ Garrett Hardin’s *Tragedy of the Commons* and Elinor Ostrom’s work on common pool resources and community-based governance of commons has long been studied, and this commons research includes the study of the

⁸³ *Id.*

⁸⁴ *Id.* (emphasis added).

⁸⁵ For more information on outer space as a commons and its relation to space governance, see *Space Governance*, OSTROM WORKSHOP, <https://ostromworkshop.indiana.edu/research/space-governance/index.html> (last visited Feb. 28, 2023). A conference on the management of space debris—a space commons issue—was recently held in 2022 by the International Association for the Study of the Commons. See *Commons in Space 2022 Virtual Conference*, INT’L ASS’N FOR STUDY COMMONS, <https://2022space.iasc-commons.org/> (last visited Apr. 22, 2023) (providing recordings of the conference).

outer space commons.⁸⁶ However, “global commons” is not defined in the Executive Order and “has no authoritative definition.”⁸⁷

⁸⁶ See generally Garrett Hardin, *The Tragedy of the Commons*, 162 AM. ASSOC. ADVANCEMENT SCI. 1243 (1968); ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990); ELINOR OSTROM, THE FUTURE OF THE COMMONS: BEYOND MARKET FAILURE AND GOVERNMENT REGULATION (2012).

⁸⁷ See John S. Goehring, *Why Isn't Outer Space a Global Commons?*, 11 J. NAT'L SEC. L. & POL'Y 573, 574 (2021) (describing the phrase “global commons” as either an “enabling concept or a constraining concept”). Goehring further explains:

When used in a military or geopolitical context, ‘global commons’ is typically used as an enabling concept. It refers to domains ‘that lie outside the exclusive jurisdiction of any particular state but may be accessed and used by those states or their nationals.’ The Obama Administration, for instance, referred to the global commons as simply ‘those areas beyond national jurisdiction that constitute the vital connective tissue of the international system.’ These domains include the high seas, the airspace outside of a state’s territorial waters, and outer space. The electromagnetic spectrum and cyberspace have also been described as global commons. This concept is enabling in the sense that these traits – lying beyond national jurisdiction and free for access by all – are thought to enable prosperity and security. ‘Prosperity of the United States depends upon its largely uncontested ability to access and use the global commons,’ according to the 2016 Joint Chiefs of Staff report *Joint Operating Environment (JOE) 2035*. JOE 2035 further asserts “[o]pen and accessible global commons,” including outer space, “are the pillars of the current international economy and empower states that use them to conduct commerce, transit, scientific study, or military surveillance and presence.”

Id. at 574–75 (footnotes omitted) (first quoting First Major John W. Bellflower, *The Influence of Law on Command of Space*, 65 A.F. L. REV. 107, 120 & n.74 (2010); then quoting U.S. DEP’T DEFENSE, SUSTAINING GLOBAL LEADERSHIP: PRIORITIES FOR 21ST CENTURY DEFENSE 3 (Jan. 2012); and then quoting JOINT CHIEFS OF STAFF, JOINT OPERATING ENVIRONMENT 2035: THE JOINT FORCE IN A CONTESTED AND DISORDERED WORLD 30 (July 14, 2016)). As a constraining concept, Goehring describes:

In an economic context, as opposed to a military or geopolitical context, “global commons” is typically used to convey a constraining concept. The concept of a “commons” may be thought of as constraining because it is often associated with notions of shared ownership, public governance, or limitations on use. Whether these constraints are viewed positively or negatively is a subjective assessment. The constraining concept is more complicated than the enabling concept because it can reflect two distinct meanings. This is likely a function of its history.

Id. at 577 (quoting Bellflower, *supra* note 87, at 120 & n.74).

The other applicable law and policy are the U.S. Space Policy Directives under the Office of Space Commerce (OSC), which is not directly under the Department of Commerce. Instead, the OSC resides in the National Oceanic and Atmospheric Administration (NOAA), an agency of the Commerce Department.⁸⁸ Although outer space is not within an ocean or atmosphere, NOAA nevertheless holds the office because what it does have is the ability to manage satellite licenses, a valuable space commodity.⁸⁹ The 2022–2026 Strategic Plan for the Department of Commerce includes Strategic Plan Objective 1.7: “Advance U.S. leadership in the global commercial space industry.”⁹⁰ The commerce benefits listed as support of Objective 1.7 include economic contribution: “In 2019, . . . the U.S. space economy accounted for 354,000 private sector jobs, \$194.6 billion of real gross output, and \$120.3 billion of current-dollar GDP.”⁹¹ The first strategy listed to support this growth is not innovation, safety, sustainability, or customer base development—it’s legal certainty and regulatory coordination.⁹²

⁸⁸ *Legal and Departmental Authorities of the Office of Space Commerce*, OFF. SPACE COM., <https://www.space.commerce.gov/law/office-of-space-commercialization/> (last visited Apr. 22, 2023).

⁸⁹ *Mission*, OFF. SPACE COM., <https://www.space.commerce.gov/about/mission/> (last visited Feb. 23, 2023). These NOAA organizations include the: Satellite and Information Service (NESDIS), which “[m]anages meteorological satellite systems and data”; Commercial Remote Sensing Regulatory Affairs (CRSRA), which “[l]icenses U.S. commercial remote sensing satellite operations”; National Geodetic Survey (NGS), which “[m]aintains the National Spatial Reference System and a GPS monitoring network of Continuously Operating Reference Stations (CORS)”; International Trade Administration (ITA), which “[a]ssists U.S. companies in exporting aerospace products”; Bureau of Industry and Security (BIS), which “[l]icenses exports of commercial spacecraft, and conducts assessments of the U.S. space industrial base”; National Telecommunications and Information Administration (NTIA), which “[c]o-manages (with FCC) radio spectrum used by satellites”; National Institute of Standards and Technology (NIST), which “[m]aintains U.S. standards used to calibrate satellites, etc.”; and the Bureau of Economic Analysis (BEA), which “[p]roduces statistics on the U.S. space economy.” *Id.*

⁹⁰ U.S. DEP’T COM., STRATEGIC PLAN 2022–2026 INNOVATION, EQUITY, AND RESILIENCE: STRENGTHENING AMERICAN COMPETITIVENESS IN THE 21ST CENTURY 25 (2022), <https://www.space.commerce.gov/space-commerce-in-docs-strategic-plan-for-2022-2026/>.

⁹¹ *Id.*

⁹² *Id.* at 26. Strategy 1 of Objective 1.7, titled Coordinate regulatory functions across domestic and international stakeholders to promote competitiveness, and increase legal certainty for U.S. commercial space businesses, states:

The Department will convene Federal, state, and international stakeholders as appropriate to identify and act on regulatory issues and opportunities for

Finally, the Artemis Accords are a nonbinding practical set of principles in support of the NASA Artemis mission that aims to land the first woman and person of color on the Moon, “heralding a new era for space exploration and utilization.”⁹³ The Accords impact ownership of outer space resources in that NASA is aware that its Artemis missions will involve international partnerships and cooperation, with numerous nations, industries, and entities.⁹⁴ To that extent, Section 10 of the Artemis Accords, titled *Space Resources*, provides:

The Signatories emphasize that the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon, Mars, comets, or asteroids, should be executed in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities. The Signatories affirm that the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty, and that contracts and other legal instruments relating to space resources should be consistent with that Treaty.⁹⁵

The policy provision appears to affirm the Outer Space Treaty of 1967, while simultaneously excepting extraction and utilization from the Treaty. The only clarity that can be derived is that space resources will be extracted and utilized; and NASA and the

commercial space businesses with a whole-of-government approach. As commercial space activities expand into new areas and business models, the Department’s Office of Space Commerce will partner with these stakeholders to coordinate regulatory functions that promote competitiveness and increase legal certainty for space businesses. Coordinated regulation will support existing space activities and ensure regulatory frameworks address emerging missions.

Id.

⁹³ ARTEMIS ACCORDS, *supra* note 80.

⁹⁴ *The Artemis Accords*, NASA, <https://www.nasa.gov/specials/artemis-accords/index.html> (last visited Apr. 22, 2023). Note that the name Artemis derives from the twin sister of the Greek God Apollo, for whom the Apollo missions were named. Brian Dunbar, *What Is Artemis?*, NASA (Jul. 25, 2019), <https://www.nasa.gov/what-is-artemis>.

⁹⁵ ARTEMIS ACCORDS, *supra* note 80, § 10.

signatories of the Artemis Accords likely believe they have the requisite authority to do so.⁹⁶

The absence of many of the space majors weakens any effect of the Accords. Of the signatories with orbital launch capability, only France, Japan, South Korea, and the U.S. are signatories.⁹⁷ Three out of the four space majors—China, India, and Russia—are not a part of the Accords,⁹⁸ which highlights a large challenge with ownership of outer space resources. Property is valuable only if others recognize it as property owned by another. Without this recognition and legal acknowledgment, disputes as to ownership and infringement are likely. These disputes raise issues related to jurisdiction and procedure—who may hear disputes brought by competing parties and what law applies? There are greater issues related to commerciality—how is title secured if title is not recognized by international partners or entities? If unsecured, what is the impact on the ability to file for bankruptcy? The backstop of bankruptcy often determines the provision of capital by lenders and investors. Without this security and backstop, is liquid lending possible? Additionally, how is property insured after extraction and

⁹⁶ As of January 2023, there were twenty-three signatories of the Artemis Accords: Australia, Bahrain, Brazil, Canada, Columbia, France, Israel, Italy, Japan, Luxemburg, Mexico, New Zealand, Nigeria, Poland, Republic of Korea, Romania, Rwanda, Saudi Arabia, Singapore, Ukraine, United Arab Emirates, United Kingdom, and the United States. Robert Lea, *What Are the Artemis Accords?*, SPACE.COM (Jan. 22, 2023), <https://www.space.com/artemis-accords-explained>.

⁹⁷ NASIC PUB. AFFS. OFF., *COMPETING IN SPACE* (2018), <https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-FNV711-0002.PDF>.

⁹⁸ ARTEMIS ACCORDS, *supra* note 80; *see also* Aidan Poling, *Space Property Rights and the Future of American Space Travel*, GEO. SEC. STUD. REV. (Mar. 4, 2022), <https://georgetownsecuritystudiesreview.org/2022/03/04/space-property-rights-and-the-future-of-american-space-travel/>. Poling notes that:

The apparent gap between Russia and China condemning the Artemis program and Accords while simultaneously recognizing and attempting to harness the potential of space resources can likely be explained by the fact that the U.S space program, driven by its commercial sector, is likely to beat Russia and China to the establishing a prolonged lunar presence. Rejecting the legality of space resource extraction may thus be seen as an attempt to undermine confidence in the long-term viability of the private space sector, discourage Western private investment, and thereby buy time for the Russian and Chinese sectors to catch up.

Id.

what is the consequence on reinsurance markets? Finally, if there are intermediaries between extraction and utilization, how does title to the property pass if title is clouded or insecure?

In 2020, NASA invited public-private partnerships, offering to pay companies to mine lunar resources, which it would then purchase.⁹⁹ By purchasing lunar resources from a company, NASA shifts the risk associated with ownership to the private firm, who must determine whether it is comfortable with the risk of acquiring possession. Does NASA intend to benefit from a status of good faith purchaser for value? Perhaps it does not matter. After all, NASA Administrator Jim Bridenstine reassured that the agency's effort would not violate the sovereignty provision of the Treaty:

The initiative, targeting companies that plan to send robots to mine lunar resources, is part of NASA's goal of setting what Bridenstine called "norms of behavior" in space and allowing private mining on the moon in ways that could help sustain future astronaut missions. NASA said it views the mined resources as the property of the company, and the materials would become "the sole property of NASA" after purchase.¹⁰⁰

The "norms of behavior" language used by Bridenstine is strikingly similar to the "customs" of the international miners who immigrated to the U.S. during the nineteenth century Gold Rush period.¹⁰¹ Those mining communities established customs that required no payment of royalty to the government for extracted minerals.¹⁰² Those customs were eventually legislated in the 1872 General Mining Law, which remains in effect today, with very little modification.¹⁰³ The result of the legislated custom means that even

⁹⁹ Joey Roulette, *NASA Sets out to Buy Moon Resources Mined by Private Companies*, REUTERS (Sep. 15, 2020, 5:51 PM), <https://www.reuters.com/article/space-exploration-moon-nasa-idUSKBN26208A>.

¹⁰⁰ *Id.*

¹⁰¹ See James M. Finberg, *The General Mining Law and the Doctrine of Pedis Possessio: The Case for Congressional Action*, 49 U. CHI. L. REV. 1026, 1030 (1982) ("[W]estern miners had already been governing themselves since the California gold rush and had already established a system of customs and rules designed to maintain order in the mining camps.").

¹⁰² *Id.*

¹⁰³ In an international law context, custom plays an important role in developing the law outside of treaties. See, e.g., ANTHONY A. D'AMATO, *THE CONCEPT OF CUSTOM IN*

today, over 250 years after the law's enactment, we do not know what hard rock minerals are extracted on federal land—land that is held in trust for the public.¹⁰⁴ NASA hopes that its practice will become space mining custom; but history has shown that regulation of extractive industry promotes the protection of public interests, both financial and environmental.¹⁰⁵

IV. CONCLUSION

Under NASA's Artemis program, the U.S. envisions a return of American astronauts to the moon and then to Mars—a grand voyage of human discovery and engineering, which may lead to settlement and habitation, all of which require outer space resources. Currently, a return-to-earth scenario that brings outer space resources back to the planet is too expensive to contemplate.¹⁰⁶ Technologies such as space elevators are not yet possible¹⁰⁷ and, as discussed earlier, return of large amounts of minerals could violently disrupt financial markets on Earth.¹⁰⁸ As

INTERNATIONAL LAW 89–90, 160 (1971) (explaining how binding customs of state practice are elicited from conduct); DAVID J. BEDERMAN, *CUSTOM AS A SOURCE OF LAW* 154 (2010) (“[F]or global custom, silence means acceptance of a new rule.”); B. S. Chimni, *Customary International Law: A Third World Perspective*, 112 AM. J. INT’L L. 1, 4–5 (2018) (stating that customs in international law “fill[] crucial gaps in the international legal system”); Statute of the International Court of Justice art. 38(1)(b), June 26, 1945, 59 Stat. 1055 (including “international custom” as one of three forms of international law and explaining it as “evidence of a general practice accepted as law”).

¹⁰⁴ See Finberg, *supra* note 101, at 1029 (explaining how the General Mining Law “broadly delegated the regulation of mining on public lands to local authorities,” imposing very few specific requirements).

¹⁰⁵ Roulette, *supra* note 99; see also Lauren E. Shaw, *Asteroids, the New Western Frontier: Applying Principles of the General Mining Law of 1872 to Incentivize Asteroid Mining*, 78 J. AIR L. & COM. 121, 148 (2013) (detailing how the General Mining Law opened up the public domain “to all for the exploitation of our nation’s mineral wealth,” and comparing this section to mining asteroids.) This Article does not describe the environmental issues regarding outer space resource extraction and use, which are incredibly important for preservation and conservation, in addition to protection of biotic life on Earth and possibly off-Earth.

¹⁰⁶ See Yarlagadda, *supra* note 75 (“Generally asteroid mining remains hypothetical, mostly because of its exorbitant cost.”).

¹⁰⁷ *Why Space Elevators?*, INT’L SPACE ELEVATOR CONSORTIUM, <https://www.isec.org/why-space-elevators> (last visited Mar. 6, 2023) (describing the reasons why a space elevator should be built).

¹⁰⁸ See Yarlagadda, *supra* note 75 (“[M]any experts argue on the flip side that asteroid mining would quickly destroy the economy of global raw materials, currently valued at about US\$660 billion.”).

such, most scenarios predict outer space resources will be used in space for construction, fuel, transportation, and other purposes. The knowledge that most of this acquisition and use of property will be done in space means it is critical to understand what is governing property—laws and treaties, which may or may be ratified, and/or customs? Most critically, how will these laws, treaties, or customs be enforced?

Property and ownership also raise concerns about equity and access. This Article previously discussed the financial value of asteroids; one asteroid, “16 Psyche, has been reported to contain US\$700 quintillion worth of gold, enough for every person on earth to receive about US\$93 billion.”¹⁰⁹ Whether or not “every person on earth” would receive such a payment is one of the outstanding questions regarding space mining—can mining in space be equitable? The answer is likely *only if we create and ensure that equity*. Take the sea as an example, which is a large natural environment, like outer space in some respects. Outside of territorial waters, the law of the sea governs bodies of water. “The law of the sea is a body of customs, treaties, and international agreements by which governments maintain order, productivity, and peaceful relations on the sea.”¹¹⁰ Like the Outer Space Treaty, the U.N. developed the Convention on the Law of the Sea, which came into force in 1958 and was ratified by the U.S.¹¹¹ However, there are landlocked countries that do not benefit from maritime access or territory. Lacking access to the sea increases the costs to transport goods, in addition to depriving those economies from maritime-associated goods, such as animals, plants, minerals, and hydrocarbons.¹¹² Likewise, countries without independent orbital

¹⁰⁹ *Id.*

¹¹⁰ *What Is the Law of the Sea?*, NAT’L OCEANIC & ATMOSPHERIC ADMIN. (Jan. 20, 2023), <https://www.oceanservice.noaa.gov/facts/lawofsea.html>.

¹¹¹ *See id.* (“The final conference, held in Montego Bay, Jamaica, in 1982, resulted in the 1982 Law of the Sea Convention (LOSC). The LOSC came into force in 1994 upon receiving the necessary number of UN signatories. While the United States ratified the 1958 Convention, as of late 2013, it had not become a party to the 1982 Convention. The United States recognizes that the 1982 Convention reflects customary international law and complies with its provisions.”).

¹¹² *See* Kishor Uprety, *Landlocked Countries and the Law of the Sea*, OXFORD BIBLIOGRAPHIES (Jan. 15, 2020), <https://www.oxfordbibliographies.com/display/document/obo-9780199796953/obo-9780199796953-0201.xml> (“Because of this geographical barrier, [landlocked countries] are

launch facilities remain dependent on those countries with launch facilities to enter outer space or Earth orbit. Moreover, those countries unable to partner with a launch facility may be barred from access to outer space resources. Equity and access, along with environmental conservation and protection, must be part of any robust outer space development initiative. Outer space mining and resource extraction could catalyze a modern era of colonization—privatization without regulation and enforcement will not likely produce an optimal accord.¹¹³ These considerations may promote less common or bespoke models of property ownerships, such as trusts and foundations.¹¹⁴

The Moon Agreement of 1979—formally, the *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*—was not ratified by the U.S.¹¹⁵ In fact, no nation with an

almost entirely dependent on neighboring transit countries for their external trade and suffer from high transaction costs, especially due to huge transportation expenses, inadequate infrastructure, and bottlenecks associated with importation and exportation requirements, as well as inefficient customs and transit procedures.”).

¹¹³ See PETER WARD, *THE CONSEQUENTIAL FRONTIER* 182 (2019) (“[W]hen companies reach the Moon and other planets, they plan to sidestep the most important treaty attempting to protect our interests in space. At every turn there is inequality, exclusivity, and potential for exploitation.”).

¹¹⁴ See Andrew R. Brehm, *Private Property in Outer Space: Establishing a Foundation for Future Exploration*, 33 WIS. INT’L L.J. 353, 374 (2015) (“After careful examination of the current legal framework concerning property rights in outer space as well as the potential for domestic legislation and international agreement to establish a system of private property rights, it becomes apparent that no singular approach is particularly well-suited to create an effective system of private property rights in outer space while maintaining the goals of peaceful and free exploration of space for all.”). This Article does not discuss the possibility of prohibiting any use or ownership of outer space resources, relying on demonstrated human history in extractive industries. There is a concept of non-ownership, however, which holds that outer space cannot be owned by a nation or any private party.

¹¹⁵ See Goehring, *supra* note 87, at 582 (“EO 13914 has a title that makes clear the focus: Encouraging International Support for the Recovery and Use of Space Resources. Much of the text focuses on repudiating the Moon Agreement, noting the United States has not signed the Moon Agreement and does not consider it ‘to be an effective or necessary instrument to guide nation states regarding the promotion of commercial participation in the long-term exploration, scientific discovery, and use of the Moon, Mars, or other celestial bodies.’ Instead, it says, the United States will seek to negotiate non-binding arrangements with foreign states regarding safe and sustainable operations for the public and private recovery of space resources.”).

independent space flight program has ratified the agreement.¹¹⁶ But it would be worth examining the Moon Agreement for its “articulation of first principles for the development of lunar resources, [which is therefore] thought by many to be the basis upon which future efforts to fix stable property rights” could rely.¹¹⁷ Prosperity requires stability of property rights, which must be recognized and enforceable.

So, what property framework or legislative environment would motivate firms to participate? Firms expect a security of tenure—a system of title to establish claims and enforceability of property rights.¹¹⁸ Both these expectations rely on a transparent and recognized system of property. But in the absence of law or treaty, custom remains as a path to establish right: it easily forms in the absence of both, out of necessity. The experience with the formation of the 1872 General Mining Law should show that while custom is appropriate and efficient for small communities, it is not workable for larger populations comprised of diverse stakeholders. Space resources as a commons, owned by none, so owned by everyone will only lead to tragedy.

¹¹⁶ *Moon Agreement*, NUCLEAR THREAT INITIATIVE, <https://www.nti.org/education-center/treaties-and-regimes/agreement-governing-activities-states-moon-and-other-celestial-bodies-moon-agreement/> (last visited Mar. 1, 2023).

¹¹⁷ *The Moon Agreement Energy History*, YALE UNIV., <https://energyhistory.yale.edu/library-item/moon-agreement> (last visited Feb. 23, 2023); see also *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, UNITED NATIONS OFF. FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/intromoon-agreement.html> (last visited Feb. 28, 2023) (“The Moon Agreement . . . reaffirms and elaborates on many of the provisions of the Outer Space Treaty as applied to the Moon and other celestial bodies, providing that those bodies should be used exclusively for peaceful purposes, that their environments should not be disrupted, that the United Nations should be informed of the location and purpose of any station established on those bodies. In addition, the Agreement provides that the Moon and its natural resources are the common heritage of mankind and that an international regime should be established to govern the exploitation of such resources when such exploitation is about to become feasible.”).

¹¹⁸ See Garshon Feder & David Feeny, *Land Tenure and Property Rights: Theory and Implications for Development Policy*, 5 WORLD BANK ECON. REV. 135, 146 (1995) (“Although there are obvious social benefits to the provision of secure property rights and to the removal of information asymmetry, there is a likelihood that private benefits of secure land ownership rights exceed the contribution of such security to society’s resource.”).

Over 100 million miles away, the Perseverance rover scans rocks to determine their chemical composition.¹¹⁹ Its mission remains one of exploration and discovery—to find answers to human questions on our place in the universe and our very origins.

Figure 3.0: Mars Perseverance Sol 708, Voted by the Public as “Image of the Week” for Feb. 12–18, 2023¹²⁰



These Martian rocks lay scattered across a desolate landscape, under a dusty beige sky. In the vastness of space, we feel little need to ponder the legal ownership or title to these geological resources examined so closely by Perseverance. The questions of possession, use, and wealth seem remote and unknown. We should remember

¹¹⁹ Matthew Brand, *SuperCam Gains New Artificial Intelligence Capabilities with AEGIS Upgrade*, NASA, (Feb. 22, 2023) <https://mars.nasa.gov/mars2020/mission/status/446/supercam-gains-new-artificial-intelligence-capabilities-with-aegis-upgrade/>.

¹²⁰ *Image of the Week—NASA Mars*, NASA, <https://mars.nasa.gov/mars2020/multimedia/raw-images/image-of-the-week/week-105> (last visited Feb. 23, 2023).

that 250 years ago, in the dry, dusty California mountains where the miners labored, those questions must have seemed similarly uninteresting and inconsequential to governments and the public. The truth is—they were always important.