Testimony of Misael Cabrera, PE
Before the
House Committee on Natural Resources
Subcommittee on Oversite and Investigations
On
Full Blast: Contrasting Momentum in the Space Mining Economy to the Terrestrial Mining Regulatory Morass

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Chairman Gossar, Ranking Member Dexter, and Members of the Subcommittee, thank you for inviting me to this hearing. My name is Misael Cabrera, and I serve as the Director of the School of Mining & Mineral Resources at the University of Arizona. The school was established to meet the urgent need for responsibly sourced mineral supplies for future generations. We do this through industry-advancing research, and by developing the interdisciplinary mining and minerals workforce of tomorrow. Today, I am not speaking on behalf of the university but as a private citizen who understands the necessity for abundant, economic minerals for our country's and our planet's future.

Space mining is not the final frontier; instead, it is the first way station in revolutionizing deep space exploration and providing off-world sources of minerals for the human species. Space mining presents an exciting alternative to the regulatory and social challenges faced by the mining sector on Earth. Given the unprecedented global demand for minerals required to support population growth, and technological advancements in medicine, artificial intelligence (AI) computing, defense, transportation, and renewable energy, exploring space mining is not only exciting but also wise. This alternative could fundamentally change how humanity utilizes resources on and beyond our planet, especially as mining grapples with increasing environmental and bureaucratic complexities on Earth. Here in the U.S., the potential for space mining is further fueled by a growing awareness of our dangerous over-reliance on foreign sources of critical minerals and the recent technological advancements in space flight.

In stark contrast to the burgeoning potential of space mining, Earth extraction is hindered by lengthy permitting delays and court challenges – especially in the U.S. The exhaustive regulatory regime means that obtaining approvals for mining operations can span years, if not decades, severely throttling the introduction of new supply streams into the global market and domestic supply. Attachment 1 presents the rigorous regulatory journey for hard rock mines. Mining operations on federal lands may have to adhere to over 50 regulatory requirements before producing a single ton of metal. These requirements, coupled with unimproved administrative processes that implement them, create decades-long delays that strain the supply chains, making the possibility of off-world alternatives attractive to both investors and start-ups.

The regulatory landscape for space mining remains markedly less developed than its terrestrial counterpart. While providing a foundational legal framework, the Outer Space Treaty of 1967 posits outer space as the province of all humankind (UNOOSA, 1967). This treaty offers limited guidance regarding the proprietorship of celestial resources. A subsequent Moon Treaty sought to prevent ownership claims over celestial bodies but has received limited ratification globally, resulting in ambiguous regulatory interpretations (UNOOSA, 1984). The absence of international regulatory consensus has opened the doors to legislation in individual countries. For example, the U.S. Space Launch Competitiveness Act of 2015 empowers American enterprises in space resource acquisition, fostering a more structured regulatory trajectory for such operations (U.S. Congress, 2015). Other countries like Luxenberg (Luxembourg Space Agency, 2017) and Japan (Library of Congress, 2021) have passed similar laws.

Federal and private-sector investments in space exploration further buoy the current momentum. These investments manifest in billions of dollars allocated to developing technologies and infrastructures necessary for successful space mining initiatives (Space Foundation, 2024). This is coupled with many start-ups eager to capitalize on the emerging space economy's opportunities (Sriram & Singh, 2024).

The state of Arizona and its land grant institution, the University of Arizona, are well-positioned to respond to the emerging space mining landscape. The university houses innovation platforms like the Lunar and Planetary Laboratory, the Arizona Space Institute, the Space Systems Engineering Laboratory, and the School of Mining & Mineral Resources. With a long history of space exploration, the university has contributed to key achievements, from helping Americans reach the moon in 1969 to developing the first spacecraft to orbit close to the sun in 2018 (Jones, 2021). Additionally, the university participates in the Arizona Space Commission, established through Arizona House Bill 2254, which aims to promote research and development in space exploration (Arizona State Legislature, 2023).

For example, the Lunar and Planetary Laboratory partnered with NASA to lead the historic OSIRIS-REx[1] Mission that launched a rocket into space, navigated to the asteroid Bennu, collected a sample, and safely brought it back to Earth. The mission aimed to better understand the early solar system and the origins of life on Earth (Lauretta et al., 2017), and key insights and discoveries are already being published (McCoy et al., 2025). An added benefit of the mission is that the OSIRIS-REx team demonstrated that all the foundational activities for space mining are plausible, if not yet economic.

Preliminary analysis of asteroid Bennu samples indicates the presence of iron, cobalt, nickel, platinum, and iridium, among other metals. Extrapolating the concentrations of the known elements to the asteroid as a whole and assuming current market prices for metals suggests that the value of the asteroid Bennu could reach upwards of $500 billion (Lauretta, personal communication, February 18, 2025). As exciting as that sounds, the cost to recover just 121 grams of material from Bennu was roughly $1.2 billion (Fishman, 2023) – millions of dollars per gram, far greater than the market value of even the most precious of metals. From a mineral economics perspective, that is an enormously negative return on investment. The cost of developing infrastructure conducive to mining in space represents a formidable obstacle yet to be surmounted. Therefore, ongoing innovation, research, and investment, especially in cost-effective propulsion and mining in harsh, waterless environments, remain crucial to transitioning from plausibility to economic applicability.

[1] Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS Rex)

History teaches us that economics is as essential as technology in free societies. For instance, the Detroit Electric sedan, despite having Clara Ford—wife of the founder of the Ford Motor Company—among its customers, could not compete with the economy of the Ford Model T after 1939 (Sadler, 2022). Only recently – roughly four decades later – have electric vehicles been able to compete with traditional internal combustion automobiles in the global marketplace. Unfortunately, our domestic mineral supply cannot wait that long.

Thus, domestic Earth mining must innovate simultaneously, if not ahead of its celestial counterpart. Breakthroughs in remote operations, automation, AI, renewable energy sources for mining equipment, water management, and responsible mineral extraction—all crucial for mining in harsh, water-scarce environments—are equally applicable to both space and Earth mining. However, dramatically reducing propulsion costs, a monumental technological challenge, is uniquely essential to make space mining economically viable.

Further, an abundant, economic, terrestrial mineral supply must undergird every technological advancement, including space mining, until it becomes self-sustaining. Domestic mining can undergo a revolution by leveraging automation and AI, energy efficiency, green leaching technologies, waste valorization, reuse, and management, creating a flywheel of multi-sector benefits for the host communities. This captures the scope and vision of the Sustainable Mining Innovation and Lifestyle Enrichment (SMILE) initiative, led by the University of Arizona in partnership with 18 educational, governmental, and industrial organizations.

Mining technology innovation alone will not unleash domestic terrestrial mineral supply – especially in the U.S. A key factor in developing a reliable domestic minerals supply chain is streamlining the Federal Government's permitting process. With layers of regulatory oversight from local, state, and federal levels, it is imperative to identify and eliminate duplication and waste from mine permitting without reducing opportunities for public input or limiting the comprehensiveness of environmental reviews. Real-world experience at the Arizona Department of Environmental Quality demonstrates that up to 90% of the total elapsed time associated with state permitting is waiting and that permitting time frames for even the most complex permit can be reduced by 60% or more (ADEQ, 2021).

Similar thought leadership is at the root of the U.S. Federal Permitting Improvement Steering Council's FAST-41[2] process. FAST-41 for Infrastructure Permitting is a "coordinated framework for improving the federal environmental review and authorization process," and on May 8, 2023, the South32 Hermosa project was the first mining initiative to gain FAST-41 coverage (Permitting Dashboard, 2023). I recommend that this process be applied to new major mining and processing projects that will produce any critical mineral or material.

Another key factor in the supply of terrestrial domestic minerals is judicial reform. Ensuring citizens retain the right to challenge government decisions while eliminating incentives for abuse and unnecessary delays is long overdue. In 2010, the USGS published a report on rare earth elements indicating that 47% of the mines experience delays related to court challenges and that 71% of the mines that had "not yet achieved" production were involved in litigation (Long et al.,

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[2] Title 41 of the Fixing America's Surface Transportation Act (FAST-41)

2010). Legislative proposals like the 118th Congress's HR 1 aimed to balance these needs, and I encourage this Congress to continue developing these concepts.

As global demand for minerals intensifies, space mining faces significant cost and technological challenges, while Earth mining deals with a cumbersome regulatory framework. Strategic foresight, investment, regulatory modernization, and scientific advancements are essential for both areas. Institutions like the University of Arizona are prepared to be dynamic catalysts, promoting the interdisciplinary solutions needed to tackle these complex issues. Success depends on balancing Earth's resources with the potential of space, guiding humanity toward a future rich in resources and exploration.

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