Illustration by MIPB Staff

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Introduction

The Earth's Moon offers many possibilities for the advancement of humanity, including the mining of essential minerals and the potential of unknown materials. In addition to the United States, other nations and numerous commercial organizations are engaged in the exploration of the Moon and beyond:

- China is currently conducting two robotic lunar missions, with three robots exploring and gathering mineral samples for return to Earth.
- Russia has successfully launched and recovered spacecraft, and has set human space-orbiting endurance records.
- Other nations are capable of launching and placing satellites into orbit.
- Commercial space ventures are on the rise and will eclipse formal government space and planetary exploration.

For the United States and the Department of Defense, the space domain will increase in complexity on Earth and in space. This is not about searching for the presence of other life forms; rather, it is about ensuring that the United States has access to, and maintains maneuvering capability within, the Earth's orbit and beyond. Accomplishing this goal requires navigating international treaties that govern space and lunar exploration, and developing policies and standards in conjunction with other nations and commercial enterprises.

Why an Interest in Lunar Activities?

The United States and Russia started their space programs in the 1940s and 1950s. Since then, the Chinese established an ambitious program of their own. By 1970, China had launched its first satellite; in 2003, it sent its first astronaut into space; and now it is building a space station. Most recently, the Chinese collected lunar soil and rocks and returned them to Earth.

From a military intelligence perspective, there are three primary areas of interest as China and other countries explore the lunar surface. First, although several of these Moon minerals are available on Earth, scientists believe that the different properties could potentially enhance the application of common construction, communications, energy transference and storage, and weapon lethality and protection measures. Table 1, on the next page, lists the minerals and elements known to exist on the lunar surface and their associated application. Second, China's current exploration of the lunar surface is a robotic mission. Similar efforts by any country or private company may accelerate human inhabitation of the lunar surface. Third, many of these exploration goals include going farther into space and to Mars. In addition to government space missions, many private organizations are conducting lunar research, some for exploration, and others for potential mining opportunities.

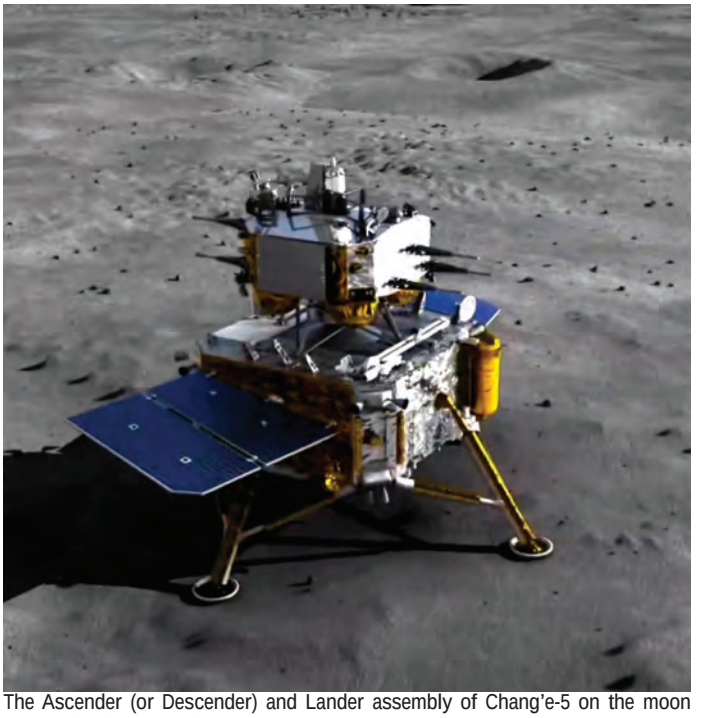
MINERAL OR ELEMENT	AVAILABILITY	APPLICATION
Al ALUMINUM	Present with other minerals. Requires extraction.	Excellent electrical conductor, and when atomized, aluminum power is a good solid rocket fuel when burned with oxygen.
Fe IRON	Abundant. Requires additional exploration for deposit validity.	Additive manufacturing, 3D printing, selective laser sintering, selective laser melting, and electron beam melting.
Ti TITANIUM	Present. Surface and subsurface extraction required.	Framing of future spacecraft.
Ca CALCIUM	Abundant.	Ceramic/silicon-based solar cells, along with creating flexible metals, electrical conductors in zero atmospheres.
Mg MAGNESIUM	Likely abundant for lunar mining at low depths.	Various alloys for aerospace, automotive, and electronics applications.
Si SILICON	Abundant as metalloid on lunar surface.	Supports solar panel arrays along with glass, fiberglass, and ceramics. High purity supports semiconductor applications.
^{3}He HELIUM-3	Present and challenging to gather. Could be exhausted if over-mined.	Application with nuclear fusion, yet questionable results. Overall, this rare earth element is more valued than gold.
C CARBON	Present.	Potential for production of lunar steel.
N NITROGEN	Present.	Mining would be difficult because of trace amounts.

Figure by Jonathan S. Dingler, MIPB

Table 1. Lunar Mineral Availability and Application

China's Chang'e Project

The Chinese Lunar Exploration Program launched its first spacecraft, Chang'e-1, in 2007. More recently, the Chinese launched Chang'e-4, arriving on the Moon's far side in January 2019. It included the Yutu-2, a robotic lunar rover equipped with the lunar penetrating radar, a ground-penetrating radar that uses pulses to image the subsurface of the Moon. In 1972, the U.S. Apollo 17 mission deployed the Apollo lunar sounder experiment while in orbit, which penetrated approximately 1.3 kilometers into the Moon's surface. Although the Chinese lunar penetrating radar data is not available, considering the technological improvements since the 1970s, it is likely the recordings are better and may have detected water and other deposits.



The Ascender (or Descender) and Lander assembly of Chang'e-5 on the moon surface[3]

In December 2020, the Chang'e-5 lunar exploration vehicle landed on the Moon. The vehicle collected samples and launched an ascender to bring the lunar material back to Earth later that month.[1] It was the first time that moon rocks and soil have been brought back to Earth since the former Soviet Union's Luna 24 mission in 1976.[2]

Who Owns the Moon?

With increased space activity in the 1950s and 1960s, many nations recognized the need to establish an international legal framework, under the auspices of the United Nations, to protect space. The 1967 Outer Space Treaty, which still exists, details numerous rules governing the peaceful exploration and use of space.[4] Although more than 100 countries have signed and ratified the treaty, it is virtually impossible to enforce.[5] The 1979 Moon Treaty reiterates most provisions of the Outer Space Treaty and adds two new concepts that address the exploitation of natural resources in outer space. However, most countries have not ratified the Moon Treaty, including the United States, Russia, and China.[6] A recent article on space law, states—

> ***Seeking clearer regulatory guidelines, private companies in the US prompted the US government, and legalized space mining in 2015 by introducing the US Commercial Space Launch Competitiveness Act of 2015. Similar national legislations legalizing extra-terrestrial appropriation of resources are now being replicated by other nations, including Luxembourg, Japan, China, India and Russia. This has created an international legal controversy on mining rights for profit….A legal expert stated in 2011 that the international issues "would probably be settled during the normal course of space exploration."***[7]

The U.S. Commercial Space Launch Competitiveness Act of 2015 was created to "facilitate a pro-growth environment for the developing commercial space industry," making it legal for U.S. companies and citizens to own and sell resources that they extract from the Moon, Mars, and beyond. Additionally, in April 2020, former President Donald Trump signed an executive order establishing that "Americans should have the right to engage in commercial exploration, recovery, and use of resources in outer space, consistent with applicable law," and that the United States does not view space as a "global commons."[8] This opens up the potential for the U.S. Government, private ventures, and other nations to consider their options in outer space. As for China, the Chinese Lunar Exploration Program is actively pursuing its goals, with its space station and series of Chang'e missions.

An important consideration for Army intelligence is how a country or an alliance of nations, including private entities, would employ capabilities on the lunar surface. Table 2 outlines potential conceptual ideas for military applications.

Conclusion

As a domain, space includes the immediate orbiting activities around the Earth, space basing (to include the inhabitation and mining of the Moon), and further exploration into outer space. While for many nations much of space exploration is currently conceptual, countries such as China are developing and conducting ambitious space operations. Therefore, the U.S. Army, Department of Defense, and various intelligence agencies have an obligation to be involved in space exploration discussions here on Earth and in actual space ventures—government or civilian.

Figure by Jonathan S. Dingler, MIPB

MISSION	PLAUSIBILITY	APPLICATION
LUNAR BASE	Likely first activity before any other concept—use of lunar materials will enable construction once a similar orbiting station module has established initial basing operations.	• Lunar surface base—Modular base station elements—access to water and power source. • Sub-lunar surface base—Use of known lunar lava tubes once surace base is complete. Lunar artificial intelligence-enabled robotic bases are more likely in advance of human occupation/habitation.
LUNAR LAUNCHING SITE	Conceptual based on success of orbiting space stations and creation of materials to form the habitat structures.	Opportunities for both Earth-to-Earth and Moon-to-other planets, or asteroid exploration and mining.
LUNAR COLLECTION ARRAY	Likely—conceptual designs.	Precision cosmological measurements via telescope observations looking at Earth for geological activities but as a stable optical surveillance collection means.
LUNAR NAVIGATION ARRAY	Most likely—concepts exist.	Lunar navigation arrays could replace or enhance existing orbiting navigational satellites.
LAUNCH MISSILES FROM MOON TO EARTH	Conceptual — challenge lies in getting missiles safely to the lunar surface. An alternative is kinetic rods launched from an orbiting satellite or lunar space station.	Nuclear weapons directed falling rod or meteorite at enemy targets.

Table 2. Lunar Application

Endnotes

1. "解放军报, 嫦娥五号探测器实施动力下降并成功着陆" [People's Liberation Army Daily, the Chang'e-5 probe carried out a power descent and successfully landed], China Military Network, Ministry of National Defense Network, December 2, 2020, http://www.81.cn/jfjbmap/content/2020-12/02/content_277167.htm.

2. Neel V. Patel, "China just brought moon rocks back to Earth for the first time in its history," *MIT Technology Review* online, December 16, 2020, https://www.technologyreview.com/2020/12/16/1014773/china-moon-rocks-back-earth-chang-e-5/.

3. The photograph of the Ascender (or Descender) and lander assembly of Chang'e-5 on the moon surface is licensed under a Creative Commons Attribution 3.0 Unported license by the China News Service, https://www.youtube.com/watch?v=b-HMhWenTM0&t=7s.

4. "The Outer Space Treaty at a glance," Arms Control Association, last reviewed October 2020, https://www.armscontrol.org/factsheets/outerspace.

5. "The Outer Space Treaty has been remarkably successful – but is it fit for the modern age?" The Conversation, January 27, 2017, https://theconversation.com/the-outer-space-treaty-has-been-remarkably-successful-but-is-it-fit-for-the-modern-age-71381.

6. Matt Williams, "Trump signs an executive order allowing mining the moon and asteroids," Phys.org, April 13, 2020, https://phys.org/news/2020-04-trump-moon-asteroids.html.

7. Charlie Bowles, "Space Law: The Commercial Space Race Begins," EM Law, March 8, 2021, https://www.emlaw.co.uk/international/space-law-the-commercial-space-race-begins/.

8. Williams, "Trump signs executive order."