

Who Owns the Moon? A Case Study on Helium-3

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Key takeaways

- Helium-3 is rare on Earth and worth about \$20 million a kilogram.
- The Moon has more of it, but in low concentrations and only a handful of places.
- It's used in quantum computing, fusion energy, medical imaging, and national security.
- Companies already have contracts worth hundreds of millions, but nobody has mined it on the Moon yet.
- Who can mine He-3 remains unsettled, a test case for how lunar resources, and the rivalries around them, get governed.

Helium-3 may be the most important material you have never heard of. It can be used to fuel fusion [1], [2], it is a critical part of the cooling systems needed for quantum computers [3], and, it is incredibly rare on Earth, commanding a price of around \$20 million per kilogram [4], [5], [6]. Helium-4 is one of the most abundant elements in the universe and on Earth, yet here helium-3 makes up only about one part in a million of all helium [7]. It is the reason several companies are racing to return to the Moon, where Helium-3 is thought to exist in much larger quantities.

Because of its rarity and value, lunar helium-3 is the first purchase a national government has ever made of a resource that has not yet been extracted from anywhere off Earth [8], [9]. The high cost of terrestrial helium-3 is what makes a case for lunar extraction and transport worth exploring [4], [5], [6]. Helium-3 may also be the first test of the international law governing extraction and ownership of lunar resources. How that test is resolved will shape not just who profits from the Moon, but whether the next phase of space activity unfolds through cooperation or through competition among a handful of states and companies. This explainer piece explains what helium-3 is, why it is useful, where it is found, and why the rules for who may mine it remain unsettled.

What Is Helium-3?

Helium-3 is a light, non-radioactive isotope of the much more abundant naturally occurring helium-4. It is primordial in origin – it was formed in the first minutes after the Big Bang and is continuously produced inside stars [10]. It is comparatively abundant in the Sun, the solar wind, and the atmospheres of gas giants such as Jupiter and Saturn [11]. The picture is very different on small, rocky, geologically active worlds. Earth formed with only a trace of primordial helium-3, most of which was lost to space over billions of years through giant impacts and continuous volcanic outgassing [12], [7]. Beyond this natural supply, helium-3 can also be made on Earth through the slow radioactive decay of tritium (hydrogen-3) from nuclear weapons stockpiles [13], or by fusing deuterium (hydrogen-2) with itself, the approach some fusion companies are pursuing to ensure their own helium-3 supplies [14].

Where Is It Found, and Why Does the Moon Have More?

In the United States, the Department of Energy's Savannah River Site, which recovers and processes tritium for the nuclear weapons stockpile, is the sole producer of helium-3 gas [13]. Similarly, Russia has historically produced helium-3 from its own nuclear weapons stockpile [15]. Production using this method is limited and essentially fixed by the tritium decay rate: around 1 kilogram a year in the United States, out of a worldwide total of less than 4 kilograms per year [16]. Since 2021, a non-weapons-related source has begun to emerge: a Canadian energy company has been recovering helium-3 from tritium produced as a byproduct of heavy-water reactor operations [3].

The Moon has more helium-3 than the Earth because its magnetic field and atmosphere are different. The Sun constantly emits a stream of charged particles – the solar wind – and a small fraction of that stream is helium-3. Earth's magnetic field and atmosphere deflect almost all of it before it reaches the ground. The Moon has essentially no global magnetic field and only the thinnest trace of an atmosphere, so for billions of years the solar wind has struck its surface directly, embedding helium-3 into the top layer of lunar soil, known as regolith [17], [18].

But saying “the Moon has helium-3” considerably overstates how abundant it is. Measurements of returned lunar regolith samples put the concentrations of helium-3 at ranges of 2.4 to 26 parts per billion by mass [2], [6], [17], [18], [19], [20], [21]. At concentrations of 10 to 20 parts per billion, companies would need to excavate massive amounts of regolith (a thousand tonnes an hour) to recover just several dozen kilograms of helium-3 a year [21]. In comparison, a large terrestrial uranium mine processing a thousand tonnes of ore per hour generates at least 100 kilograms of uranium per **hour** [22]. A lunar helium-3 operation moving ~9 million tonnes of regolith per year would have a throughput comparable to a medium terrestrial mine, while producing a final product measured in tens of kilograms per year, not tonnes.

Helium-3 is also unevenly deposited on the lunar surface [17]. Researchers use remote sensing assessments of soil composition to model helium-3 across the lunar surface [17], [23]. Solar-wind helium-3 is retained most effectively by ilmenite, an iron-titanium oxide, which is why titanium-rich mare basalts hold the most [18], [19]. These titanium-rich regions point to a short list of candidate sites: the craters Grimaldi and Riccioli, Mare Moscoviense, and parts of Oceanus Procellarum, Mare Tranquillitatis, and Mare Fecunditatis [24]. These are estimates, not measurements. Even the most optimistic models point to just a few tens of parts per billion, which is why claims about helium-3 as a driver of lunar mining have sometimes been judged as exaggerated [17].

Why Do People Want It?

Helium-3 is important for three distinct uses: it cools the machines behind quantum computing, it is one of two candidate fuels for fusion energy, and it is used in medical imaging and nuclear security screening.

Quantum computing

The leading approaches to building quantum computers use small superconducting circuits as quantum bits, or qubits [25]. Those circuits only behave as required when cooled to within a fraction of a degree of absolute zero, far colder than deep space. The machines that do this cooling

are called dilution refrigerators; they work by circulating a mixture of helium-3 and helium-4 [3], [26].

Quantum computing is the single fastest-growing source of demand for helium-3 today, and it is also where the first large, confirmed commercial supply contracts for lunar helium-3 have appeared [27]. It has also attracted concern about dependence on a single scarce input: global manufacturers of dilution refrigerators and their customers are exposed to helium-3's high cost and limited supply as quantum computing scales toward larger machines. In response, researchers in the field are investigating several ways to cool superconducting qubits without relying on helium-3, among them cooling systems built around magnets, cooling circuits etched directly onto the chip itself, and even using light rather than a circulating gas to carry heat away. None of these alternatives has yet displaced the dilution refrigerator but their existence shows that helium-3 dependence is treated as something to be engineered around, not accepted as permanent [3].

Fusion energy

Fusion is the reaction that powers the sun. It has been pursued as a terrestrial power source for decades because, unlike the fission reactions used in today's nuclear plants, fusion produces no long-lived, high-level radioactive waste and carries no risk of a runaway chain reaction.

Most fusion power research today is built around one specific reaction: deuterium and tritium (D-T), two heavier isotopes of hydrogen, fusing into helium-4 and a high-energy neutron [28], [29]. D-T is the easiest reaction to achieve, reaching fusion conditions at a lower temperature than other fuels, but that neutron carries most of the reaction's energy and gradually damages the reactor's walls [29], [30].

Helium-3 matters because a deuterium-helium-3 (D-He-3) reaction replaces most of that damaging neutron with a charged proton, meaning far less material damage, a longer-lasting reactor, and the possibility of converting the reaction's energy into electricity more directly [29], [31]. D-He-3 comes with real drawbacks, however: it ignites at roughly four times the temperature D-T needs, around 700 million degrees Celsius, since the stronger repulsion between the nuclei is harder to overcome [29], and the fuel itself is far scarcer than tritium. Some developers plan to breed their own helium-3 from deuterium rather than rely on external supply, since D-D side reactions produce it directly, along with tritium that decays into more [14].

In practice, the fusion industry is split between those building toward D-T and a smaller group pursuing D-He-3. Only few developers today are planning to buy helium-3 on the open market; this is worth remembering when fusion is cited as the reason lunar helium-3 will be valuable [14], [32], [33], [34].

Medical imaging and national security

For decades, helium-3 has also been used in a specialized type of lung-imaging scan in which a patient inhales a small volume of helium-3 gas as a contrast agent to produce much higher resolution images of lung ventilation in magnetic resonance imaging, MRI, scans [35], [36]. Helium-3 is also a key ingredient in radiation detectors used to screen for smuggled nuclear material at borders and ports. Demand for radiation detectors rose sharply after 2001, draining the U.S. government's stockpile of helium-3 and triggering a shortage that forced federal agencies to ration the remaining supply [37].

As with quantum computing, helium-3's scarcity has pushed researchers toward alternatives. A team at the National Institute of Standards and Technology developed a neutron detector using a scintillator made from zinc sulfide and lithium-6 fluoride, which are abundantly available. The scintillator reached greater than 90 percent detection efficiency, rivaling helium-3-based detectors without requiring the scarce isotope [38], [39].

Who Is Actually Trying to Mine It on the Moon?

To date, no one has extracted helium-3 from the Moon. Some argue that it is not feasible: a 2022 U.S. Geological Survey assessment classified lunar helium-3 as an "inferred unrecoverable resource," meaning its abundance is extrapolated rather than directly measured, and no extraction technology is expected within 30 years [40]. The most advanced mining effort is by Interlune, a Seattle-based company founded in 2020 that is developing a full-scale regolith-processing excavator system and separately developed a terrestrial process for extracting helium-3 from natural gas streams [41].

Interlune's executive chairman, Harrison Schmitt, is both the only geologist to have walked on the Moon, during Apollo 17 in 1972, and the author of a 2006 book making an early, detailed case for exactly this kind of venture [2]. Interlune has also signed the first confirmed commercial agreements for lunar helium-3: a multi-year supply contract with the Finnish cryogenics manufacturer Bluefors for up to 10,000 liters (roughly 1.3 kilograms) of helium-3 annually, for delivery between 2028 and 2037, reported at a value above \$300 million; a separate agreement with the quantum hardware company Maybell Quantum; and a 2025 agreement to sell three liters of lunar helium-3 to the U.S. Department of Energy, the first time a national government has purchased a resource that has not yet been extracted from anywhere beyond Earth [5], [8], [42]. Taken together, Interlune's publicly disclosed binding purchase orders across these customers reached about \$500 million by September 2026 [4].

How economically feasible lunar extraction is remains uncertain. Rough, order-of-magnitude estimates put the cost of extracting a kilogram of lunar helium-3 at \$20 to \$100 million, well above the roughly \$20 million for terrestrial helium-3 today [43]. One illustrative calculation based on Interlune's own excavator design suggests a single unit would yield only about 25 to 30 grams (roughly 190 to 225 liters) a year in continuous operation [44]. Meeting the volumes in Interlune's contracts would therefore require many such units running at once, a fleet-scale buildout the company has not yet detailed publicly [44]. Interlune itself says lunar extraction is unlikely before "the early 2030s," even if its 2028 lander mission succeeds [45].

Against that uncertain timeline, the customer commitments create a further problem Interlune cannot solve with hardware alone: delivery dates on some contracts arrive years before lunar extraction could plausibly reach meaningful scale. Interlune's answer has been to try to generate revenue, and prove its separation technology, on Earth first [16]. Interlune's "Cold Capture" process, developed in part under a contract with the U.S. Air Force's innovation arm, uses cryogenic distillation to pull trace helium-3 out of ordinary helium at existing liquefaction plants, the same separation principle the company intends to later apply to gas released from lunar regolith [16]. In 2026, the company reported producing helium-3 at 99 percent purity from standard industrial-grade helium using this method, and has said that deploying Cold Capture broadly across

existing U.S. helium infrastructure could generate up to 2.5 kilograms of helium-3 a year, tripling the roughly one kilogram the United States currently produces annually from tritium decay (global production is under four kilograms a year), though this would still fall well short of the volumes implied by the company's offtake contracts [16].

Interlune is not the only entrant to the helium-3 market. Black Moon Energy has publicly described contracts to supply lunar helium-3 to the U.S. Department of Energy and to fusion companies [9], [46]. In 2026 it signed a strategic supply agreement with the fusion company TAE Technologies, which described the arrangement as an alternative fuel-supply option that "provides TAE's technology with future flexibility, depending on how fuel markets change over the long-run" [34]. Separately, another company, Pulsar Helium, has reported a terrestrial helium-3 discovery independently measured by outside laboratories, offering a possible earthbound alternative to lunar extraction [47], [48].

Can companies extract and sell lunar Helium-3?

The Treaties: 1967 and 1979

The main international agreement governing activity on the Moon is the 1967 Outer Space Treaty (OST). Article I states that the exploration and use of outer space, including the Moon, "shall be carried out for the benefit and in the interests of all countries... and shall be the province of all mankind" [49]. Article II goes further, stating that outer space, including the Moon, "is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means" [49]. That second provision was written at the height of the Cold War, primarily to stop the Moon from becoming an extension of territorial competition between states, and it has succeeded on its own terms: no government has yet claimed lunar territory as its own. What neither provision settles is a question that did not exist in 1967: whether a private company may extract a specific resource, such as helium-3 in a particular crater, and sell it, without that act itself amounting to the kind of appropriation the treaty prohibits, or without undermining the "benefit of all mankind" principle Article I sets out. The treaty's drafters were writing for an era of government-led scientific missions, not commercial mining, and the text is silent on the distinction between claiming land and extracting what is in it.

The 1979 Moon Agreement went further than the Outer Space Treaty, explicitly calling the Moon's resources the "common heritage of mankind" and calling for an international regime to govern their exploitation once it became feasible, including sharing the benefits among all countries [50]. In practice, the Moon Agreement has had little effect on today's activity: it has been ratified by only 17 states [51]; Neither the United States, Russia, China, nor any other country with an active Moon program has ratified the Moon Agreement so the common heritage obligation it created does not bind anyone currently capable of extraction.

National Laws

Several countries moved to settle the question of resource ownership with domestic law. The United States was first, with the Commercial Space Launch Competitiveness Act of 2015, which grants U.S. citizens and companies the right to possess, own, transport, use, and sell any space resource they obtain [52]. Luxembourg followed in 2017 with a law extending the same space resource ownership right to companies incorporated there, explicitly positioning itself as a

jurisdiction of choice for space resource ventures [53]. The United Arab Emirates adopted a comparable framework in 2019 as part of its broader space sector law [54]. Japan became the fourth country to pass domestic legislation in 2021, granting a government permit holder ownership of the resources it extracts under an approved activity plan [55]. None of these laws claims territory; each asserts that a resource, once extracted, belongs to whoever extracted it; and each was enacted unilaterally, without international agreement.

In 2020, the United States made its rejection of the common-heritage framing explicit Executive Order 13914, which stated that outer space “is a legally and physically unique domain of human activity, and the United States does not view it as a global commons...,” The order directed the Secretary of State to object to any attempt to treat the Moon Agreement as reflecting customary international law [56]. The order was issued roughly six months before the Artemis Accords were first signed.

The Artemis Accords

The Artemis Accords, launched in October 2020 [57], were the U.S.’s attempt to build a framework of voluntary norms to fill in gaps and clarify terms in the Outer Space Treaty. The Accords were established by NASA, in coordination with the U.S. State Department, along with seven signatory countries: Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, and the United Kingdom. The list of signatories has grown steadily since, reaching 76 by September 25, 2026, to include Brazil, India, Saudi Arabia, Mexico, and Nigeria, along with most of the European Union [58]. Notably absent are Russia and China, the two other major spacefaring powers, which have not signed on. One key provision of the Accords is Section 10 which states that extracting space resources “does not inherently constitute national appropriation” [57].

Russia stated that the Artemis Accords principles are “too U.S.-centric” [59]. Others have raised concerns that Section 10 undermines international law by legitimizing deviation from the OST [59]. Beyond resource claims, the Accords also introduce the concept of “safety zones” around an operator’s activities, intended as a coordination mechanism to prevent harmful interference between operators rather than a territorial claim. Critics have pointed out that because the zones are established unilaterally by whichever operator arrives first, and because no competing operator is likely to set up immediately next door, the mechanism can function in practice as a first-in-time claim to the best terrain, and the resources of an area, and could violate the non-appropriation principle of the Outer Space Treaty [60].

The UN Process

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) established a dedicated Working Group on Legal Aspects of Space Resource Activities in 2022 [61]. The working group continues to meet annually and has produced a set of initial recommended principles [62], but has not produced a binding instrument. Its discussions reflect how hard it is to resolve the underlying questions: how to treat competing claims over the same site, what obligations an operator owes other states, and what, if anything, non-spacefaring countries are owed under the common heritage language of the OST.

Where Rivalry Could Increase

Meanwhile, because genuinely promising helium-3 sites appear to be limited to a short list of craters and regions rather than distributed evenly across the Moon, the question of who may operate at any one of them is not an abstract future concern; it is a dispute waiting for a second serious claimant to show up. Currently, both the Artemis Accords and the China-Russia International Lunar Research Station (ILRS) have concentrated their early efforts on the lunar south pole, drawn primarily by its water ice, even as individual companies like Interlune pursue helium-3 sites elsewhere on the Moon. But, the governance gap between the two coalitions may matter more than the geography. The Artemis Accords hold that extracting space resources does not inherently constitute national appropriation and provide for safety zones around operations; the ILRS, by contrast, plans resource utilization research but has published no legal position of its own on resource rights. Announced jointly by China and Russia in 2021, the ILRS has since added national partners including Belarus, Pakistan, Azerbaijan, South Africa, Egypt, Nicaragua, Thailand, Serbia, and Kazakhstan, three of which have also signed the Artemis Accords, with the China National Space Administration stating its aim of involving as many as 50 countries by the 2030s [63], [64]. Today, no international mechanism exists to resolve a dispute over a resource site; the COPUOS working group is drafting non-binding principles, not a dispute-resolution body. If a genuinely promising helium-3 site is ever claimed by either side, that absence stops being a legal technicality and becomes an operational one.

The Open Questions

Helium-3 sits at an unusual intersection of strategic interests: a resource with genuine technological promise; a handful of financial commitments already in place; concentrated in only a few places on the one nearby body where it is comparatively abundant; and no settled answer to who has the right to extract it or how much of it the market will actually need. Whatever framework ends up governing helium-3 extraction, if it happens, will likely become the precedent other space resources are governed by too, from lunar water to asteroid metals. That matters because a sustained human presence on the Moon will require in-situ resource utilization at a larger scale, with water supplying drinking water, oxygen, and rocket propellant.

Those questions are what will determine whether helium-3 becomes the first pillar of the lunar economy or another chapter in a history of space resource ventures that generated more headlines than output. For policymakers, though, the more important question is not whether helium-3 itself succeeds, but whether the rules governing it get written deliberately, before the first real dispute, or reactively, after one.

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