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Rubidium

An Overview

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Executive Summary

Rubidium is a rare alkali metal whose strategic importance is defined by the irreplaceability of its applications. Its exceptionally low ionization energy and resonant stability make it the material of choice in atomic clocks, precision timing infrastructure, fiber optics, specialty optical glass, cardiac imaging, and an expanding range of next-generation technologies – including quantum networks, solar cells, and solid-batteries. In each of these applications, substitution by lower-cost alternatives entails a measurable and, in many cases, unacceptable loss of performance or form factor. Industries that are becoming increasingly dependent on rubidium in its various forms include telecommunications (5G), aerospace, AI data centers, military, quantum computing, solar power, and medical imaging.

The global rubidium market overall is forecasted to reach approximately US$8 billion by 2033, growing at a 5.62% CAGR from 2023. Demand is currently anchored by fiber optics, specialty optical materials, and rubidium atomic clocks. Near-term growth is driven by the global 5G rollout – which requires atomic grade synchronization at every base station and AI data centers requiring low-jitter timing infrastructure. Over the medium to long term, quantum networking and perovskite solar cells represent high-consumption applications as both technologies approach commercial scale.

From a valuation perspective, rubidium has a unit price of approximately US$128 per gram for refined metal and US$1,244 per kilogram as rubidium carbonate and is typically produced as a byproduct of some lithium mines – representing a premium of approximately 56x over lithium carbonate at current prices. In 2025, refined compounds were processed solely from existing stockpiles in China and Germany. The United States has been 100% import-dependent since 1988 with no domestic primary production on record, and all North American demand is currently met by China, Russia, and Germany. This concentration of supply in geopolitically sensitive jurisdictions has prompted the U.S. and Japan to designate rubidium an emerging critical metal, mirroring the policies that preceded strategic government interventions in the lithium supply chain.

A localized North American supply chain could begin to take shape. More people in the state of Nevada are employed in Nevada's critical minerals industry than in its gold mining industry. Several junior mining companies are reporting rubidium occurrences in lithium-bearing clay deposits in the state. Nevada Lithium Resources successfully demonstrated rubidium liberation at its Bonnie Claire Project as a recoverable byproduct – the first proven instance of this in a sediment-hosted lithium system. Early-stage developments suggest that local primary rubidium production from district-scale deposits could materially improve downstream project economics while simultaneously establishing the domestic supply infrastructure from which defense, telecommunications, technology and energy sectors will benefit.

The next decade is likely to reward early entrants to the rubidium ecosystem that establish reliable resources and secure localized supply chains ahead of accelerating demand.

1.1 Properties

Rubidium is a soft, silvery-white metallic element belonging to the alkali metal group of the periodic table. It is among the most electropositive of the stable alkali metals with a high chemical reactivity, similar to potassium and sodium. Rubidium's value is driven by its exceptionally low ionization energy and high photoelectric sensitivity, which enable critical applications in atomic clocks, advanced optics, specialty glass, and next-generation electronics – uses where substitution by lower-cost alkali metals degrades performance.

Rubidium is estimated to be the sixteenth most abundant element in the Earth's crust. Recent assessments suggest that its natural abundance may be greater than previously believed. Although no minerals are composed primarily of rubidium, the metal occurs in appreciable concentrations in several potassium-bearing minerals including lepidolite, pollucite, and carnallite, as well as trace amounts in zinnwaldite and leucite.

1.2 Uses

1.2a Advanced Electronics and Communication:

i) Atomic Clocks

Rubidium's unique properties provide a level of oscillatory stability that quartz oscillators cannot approach. This physical property is the foundation of rubidium's largest and most commercially established application: atomic timekeeping. Every major global navigation satellite system ("GNSS") – GPS ("Global Positioning System"), Galileo, GLONASS, and BeiDou – relies on onboard atomic clocks to generate the precise timing signals, from which ground-level positional accuracy is derived. The quality of a user's position fix is a direct function of the stability of those clocks, and rubidium has been the standard for satellite-based timekeeping for decades: compact and light enough to fly, stable enough to anchor continental navigation grids.

ii) Telecommunications

The rollout of 5G has imposed a change in timing requirements across telecom infrastructure, and 6G will raise the bar further. Earlier mobile generations operated comfortably with microsecond-level timing tolerances, but 5G does not. Advanced features require sub-nanosecond synchronization across thousands of distributed base stations – a standard that GNSS alone cannot reliably meet in dense urban environments, where satellite signals are routinely obstructed, degraded, or deliberately spoofed. Rubidium oscillators are increasingly embedded directly into base station hardware as the resident timing authority, providing continuous atomic-grade synchronization independent of GNSS availability.

iii) AI Data Centers & GPU Infrastructure

Large-scale distributed GPU workloads are acutely sensitive to inter-node timing drift. When thousands of processors execute parallel training runs, desynchronization corrupts calculations, degrades throughput, and can force expensive restarts of training runs that cost millions of dollars per hour. Rubidium oscillators serve as the holdover timing authority in these environments, maintaining synchronization during signal outages and in underground or shielded facilities where satellite signals cannot penetrate. There can be greater than 10,000 rubidium oscillators in an advanced AI data center.

iv) Chip Scale Atomic Clocks (CSAC)

A Chip Scale Atomic Clock is a miniaturized rubidium atomic clock small enough to fit in the palm of a hand, light enough to be worn in the field, and efficient enough to run on a battery. Where conventional rubidium clocks are fixed infrastructure – installed in data centers, base stations, and satellite ground stations – the CSAC takes the same atomic precision and makes it portable. This opens deployment environments that full-size clocks cannot reach: soldier navigation systems in GNSS denied terrain, autonomous vehicles, deep-sea sensors, and remote infrastructure far from both satellite reception and grid power. More than 100,000 commercial units have been shipped since the technology was first commercialized in 2011. In January 2025, Microchip Technology launched a second-generation, low-noise CSAC with a smaller footprint and wider operating temperature range.

1.2b Medical Applications

i) Cardiac PET Imaging

Rubidium plays a critical role in cardiac imaging. The isotope rubidium-82 is the most widely used radiotracer in cardiac Positron Emission Tomography (PET) scanning, and its adoption as the diagnostic tool of choice in nuclear cardiology reflects a set of physical properties that competing tracers have not been able to replicate in a clinically practical form.

1.2c Quantum Photonics & Next-Generation Networks

i) Quantum Memory

The fundamental problem with building a quantum network is that light – even a single photon carrying encoded information – gets lost in fiber over distance. Unlike a classical signal, it cannot simply be amplified. Amplifying a quantum signal destroys the information it carries. This means that without a way to catch, hold, and retransmit quantum information, a global quantum network is physically impossible.

Rubidium solves this. A cloud of rubidium vapor, under the right laser conditions, can absorb an incoming photon's information to store it as a collective excitation of the atomic ensemble, and release it back out on demand, intact. It functions, in effect, as a quantum memory: a buffer that holds quantum information the way a relay station holds classical signal. Devices built on this principle have already been demonstrated in field-deployable form packaged in standard hardware, ready to be installed in real network infrastructure with storage capability exceeding 95%.

ii) Quantum Repeaters

Quantum memory alone does not solve the distance problem. To span intercontinental distances, quantum networks need repeater stations – nodes spaced along a fiber route that store quantum information, confirm successful transmission across each segment, and then pass it forward. Rubidium is the leading material candidate for these repeater nodes, for one commercially decisive reason: its natural operating wavelengths are compatible with the fiber optic cables already installed around the world. This means quantum repeater networks built on rubidium can be layered onto existing telecommunications infrastructure, rather than requiring new cable to be laid. Research has already demonstrated rubidium-based quantum communication across long distances, further supporting rubidium's role in the future of quantum computing.

1.2d Energy – Solar & Battery Applications

i) Perovskite Solar Cells

Rubidium is used as a stabilizing additive in perovskite solar cells, the technology widely expected to define the next phase of the solar industry. A small quantity of rubidium incorporated into the perovskite material during manufacturing stabilizes the crystal structure, reduces energy losses, and significantly extends the cell's operational life. The efficiency impact is material: cells using rubidium have demonstrated stable power conversion efficiencies above 21%, retaining 95% of that performance after 500 hours of continuous operation. Without rubidium, perovskite solar cells are unstable when exposed to heat and moisture, and degrade quickly, so as perovskite solar scales toward mass production, rubidium has potential to scale with it.

ii) Batteries

In lithium-ion and sodium-ion batteries, rubidium is used as an electrolyte additive that directly improves battery safety and longevity. A small concentration of rubidium ions in the electrolyte suppresses dendrite formation – the degradation process responsible for battery fires and capacity loss – producing cells that cycle more safely and retain their capacity significantly longer. In sodium-ion batteries, rubidium additives have improved cycle retention from 80% to over 95%. In solid-state batteries, rubidium is incorporated into the electrolyte material itself, improving ion conductivity and reinforcing the same safety benefits. Rubidium is used in specialized high-power solid-state cells that enable efficient operations in extreme temperatures (-40°C to 100°C).

1.3 Demand

Rubidium demand remains limited due to constricted supply but is driven by high-tech and medical applications where no effective substitutes exist. The most consistent need arises from the production of rubidium atomic clocks and timing modules, which are deployed in communication networks, disciplined systems and emerging clocks. The rubidium atomic clock sub-market alone was valued at approximately US$174 million in 2024 and is projected to reach US$314.6 million by 2033 at a 6.8% CAGR, with the broader atomic clock market expected to grow from US$651.6 million in 2026 to US$1.28 billion by 2036. The rollout of 5G infrastructure is a particularly significant near-term driver: each base station requires rubidium-powered atomic clocks for sub-microsecond synchronization, and the 5G service sector is projected to generate billions in cumulative revenue, a direct and sustained tailwind for rubidium demand. The United States Naval Observatory timescale, which serves as the US military frequency standard, is itself anchored by a network of six USNO rubidium fountain clocks, underscoring how deeply embedded rubidium already is in sovereign defense infrastructure.

Specialty glass remains the single largest demand segment, accounting for 42.85% of global rubidium consumption in 2025 and growing at 6.15% CAGR through 2031. Rubidium carbonate is used to reduce electrical conductivity in high-refractive-index optical glass, improving stability and durability in fiber-optic telecommunications networks, a market that continues to expand with global broadband and 5G infrastructure build-out. Medical imaging acts as another driver, with rubidium-82 PET imaging displacing older tracers in cardiology departments across the United States, Canada, and Germany. The isotope's 75 to 76-second half-life enables on-demand myocardial perfusion scans without daily radiopharmaceutical deliveries, and multiple generator systems now hold FDA and EMA clearance, steadily lowering the barriers to hospital adoption.

Future rubidium demand is increasingly linked to quantum technologies and advanced photonics, where cold-atom clocks, quantum sensors and integrated photonic circuits often use rubidium as the active element. The USGS confirms that rubidium atoms are used in the development of quantum mechanics-based computing devices, describing this as an application with potential for relatively high rubidium consumption as the technology matures. In photonics, rubidium compounds and vapor cells play an essential role in precision optics and nonlinear devices, including frequency references, slow-light media and emerging integrated photonic circuits, which stabilize lasers, clean up optical signals and improve overall device performance. Artificial intelligence and cloud data centers are another area that may potentially drive future demand, as GPU-dense facilities require extremely precise, low-jitter time and frequency synchronization, and vendors increasingly promote atomic clock-based architectures to provide secure, resilient timing for large networks.

A potential large contributor to demand could come from perovskite solar cells. Rubidium is important to the manufacturing of perovskite crystals to stabilize the crystal and enhance its efficiency. This allows the solar cell to produce more electricity and be exposed to the environment for better and longer operations for thin-film solar applications, which are vast. Perovskite solar cells are considered the next wave of solar deployment primarily because they can be "printed" like newspapers at low temperatures, making them significantly cheaper and more versatile than traditional silicon panels.

Currently, all North American demand is being met by China, Russia, and Germany, increasing the need for a localized supply chain to avoid bottlenecks caused by geopolitical conflicts. The USGS Mineral Commodity Summaries 2026 confirms the United States has been 100% net import reliant for rubidium since 1988, with no domestic primary production recorded in 2025. The global picture is equally precarious: no rubidium ore production was reported anywhere in the world during 2025, with refined compounds being processed in China and Germany solely from existing stockpiles, which the USGS warns may be depleted in the near future without new mineral extraction coming online.

1.4 Supply

The principal rubidium-bearing minerals, lepidolite and pollucite, contain up to approximately 3.5% and 1.5% rubidium oxide respectively, and are mainly found in zoned pegmatite deposits. Although such resources occur in many regions worldwide, rubidium production remains tied almost entirely to byproduct recovery from other mineral extraction, with China currently dominating the global supply. No reliable data was available to determine global supply; however, Australia, Canada, China, and Namibia were estimated to have reserves totaling less than 200,000 tonnes. As a result, the rubidium supply chain is geographically constrained and opaque, with the United States being 100% import reliant for its rubidium supply.

Recent years have seen a significant increase in exploration and development activity focused on Nevada's large-scale clay-hosted lithium deposits. As these district-scale systems continue to advance through drilling, resource delineation, and metallurgical testing, companies have increasingly identified meaningful rubidium mineralization associated with the clay horizons. Nevada Lithium recently demonstrated the successful recovery of rubidium as a byproduct at its Bonnie Claire sediment-hosted lithium project in southern Nevada, highlighting the broader strategic potential of these deposits. With several additional district-scale clay-hosted lithium projects emerging across Nevada, the United States is increasingly positioned to develop a domestic rubidium supply chain. Continued advancements in extraction and processing technologies could establish the U.S. as a major producer and exporter of rubidium products, supporting both domestic manufacturing demand and global markets through secure North American supply.

1.5 Market Dynamics

Market dynamics for rubidium are shifting as governments increasingly recognize its strategic importance to emerging technologies, with the U.S. and Japan already designating rubidium as an "emerging critical metal." Although current commercial usage remains relatively small, expectations of future growth are stimulating early-stage exploration and supply-chain positioning. According to Spherical Insights, the global rubidium market is forecast to reach approximately US$8 billion by 2033, growing at a CAGR of 5.62% from 2023 to 2033.

Demand is anchored in high-technology sectors, where aerospace and defense firms (such as Frequency Electronics and Safran S.A.) deploy rubidium atomic clocks and frequency standards for navigation, secure communications, and mission-critical timing, while telecommunications and network infrastructure rely on rubidium-based timing modules for synchronization.

Scientific instrumentation, specialty glass, and advanced materials applications further support market growth through the use of high-purity rubidium compounds.

As adoption accelerates across satellite navigation systems, telecommunications, and precision measurement markets, the next decade is likely to reward early entrants that establish reliable resources and stable localized-supply chains ahead of demand.

1.6 Value Compared

Based on published metal quotations, the resulting gold equivalent figures indicate that even low grades of rubidium can imply high contained-metal value relative to conventional precious-metal benchmarks, reflecting the intrinsically high unit prices of these elements. Rubidium carbonate pricing of US$1,244/kg implies a value approximately 56x higher than lithium carbonate at US$22/kg, representing a very large opportunity for early players.

Rubidium Pricing		
Metal	*US$/g*	128
Carbonate	*US$/kg*	1,244

1USGS, Mineral Commodities Summaries, 2025

Rb Grade (ppm)	Value ($/tonne)	Au Eq (oz/tonne)
100	12,832	3.21
200	25,664	6.42
400	51,328	12.83
600	76,993	19.25
800	102,657	25.66
1000	128,321	32.08

Gold-equivalent ("AuEq") grades are illustrative gross value equivalents calculated on a contained-metal basis using a gold price of US$4,000/oz; and a rubidium reference price of US$128 per 1-gram ampoule at 99.75% metal basis (≈ US$128.321/g contained Rb). Calculations assume 100% metallurgical recovery and 100% payability and do not include processing costs, transportation, refining charges, product-form discounts, or market-volume considerations. Rubidium prices reflect small-lot specialty metal quotations rather than bulk commercial contract pricing; therefore, AuEq values should be viewed as comparative indicators only and not as estimates of economic cut-off grades or project revenue.

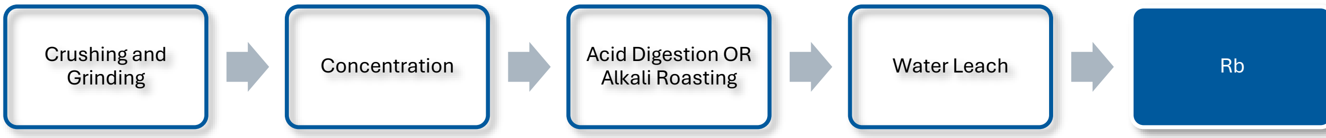
1.7 Substitution Risks for Rubidium

From a strategic perspective, rubidium exhibits low substitution risk in its highest-value applications. Its unique combinations of ionic size, polarizability and reactivity are central to precision timing devices, advanced perovskite and glass materials, and selected medical isotopes. While lower-spec applications can sometimes switch to cheaper alkalis or, in limited cases, substitute rubidium with cesium, such changes usually entail measurable losses in performance and efficiency. In the core use cases that drive strategic importance, such as atomic clocks and high-performance electronic and optical materials, there are currently no direct substitutes, leaving end-users structurally dependent on a secure, long-term supply of rubidium.

Due to supply constraints and import reliability, new projects often require strategic partnerships, similar to Lithium Americas partnering with General Motors and the U.S. Department of Energy. In the next decade, we could potentially see the public sector work with junior explorers to help establish a localized supply chain.

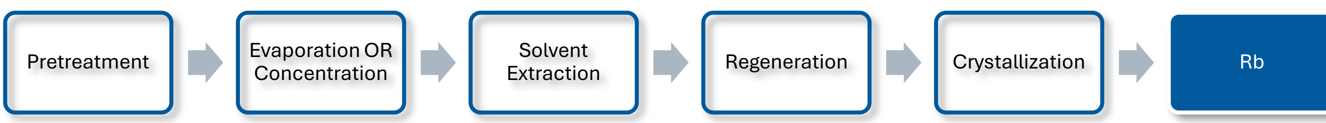
1.8 Extraction

Pollucite



Lepidolite

Brine



While process development has historically focused on a single main product (lithium or cesium), contemporary flowsheets are increasingly pursuing a comprehensive recovery, with rubidium extracted alongside other alkali metals from pegmatite, silicate and brine resources.

Recent exploration of lithium-bearing clay deposits in Nevada has revealed that these systems can also host measurable concentrations of rubidium, highlighting their potential role in future North American critical-mineral supply chains. Drill programs at several Nevada claystone projects have reported significant rubidium within lithium-rich clay layers, with assays demonstrating hundreds of parts per million, suggesting they could be recovered as valuable byproducts during lithium processing. Because rubidium is strategically important for high-precision electronics, telecommunications, and other advanced technologies, the development of such domestic deposits could help establish localized supply chains in North America, reducing reliance on Chinese-controlled production and supporting the infrastructure demands of emerging sectors such as artificial intelligence and large-scale data centers.

1.9 Sources

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