HALLGARTEN + COMPANY

Metal Review

Christopher Ecclestone
cecclestone@hallgartenco.com

Sergei Shulin
sshulin@hallgartenco.com

Cesium (Cs):

Breaking the Chinese Stranglehold

December 2025

Wednesday, December 17, 2025

Cesium

Breaking the Chinese Stranglehold

- \+ **Cesium production has effectively ceased from one of the two major mines, while the other is reportedly subject to an on/off ore export ban**
- \+ **The tight (to non-existent) supply situation for Cesium provides an opportunity for companies that can show a viable deposit for potential exploitation**
- \+ **Cesium formate is currently under the exclusive control of Sinomines and any move to break Chinese dominance would be welcomed by major drillers**
- \+ **All attempts to elucidate the real cost of mining and the margins and profits (or losses) for Cesium are elusive**
- \+ **China's dominance of production sources over the opportunity for a *de novo* non-Chinese producer to claim strategic status (and thus funding)**
- \+ **We highlight listed companies with Cesium MREs, or meaningful showings**
- × **The control of the above-ground Cesium stocks and current mining and distribution/processing by Sinomines makes Cs the element MOST totally dominated by Chinese interests**
- × **Cesium's tendency to explode upon contact with oxygen creates storage and transportation issues**
- × **Pricing information is opaque making economics of production/processing somewhat incalculable**
- × **Rubidium is the lower cost (but less accurate) alternative to Cesium for Atomic clocks and a potential challenger to Cesium in drilling formates**

On Cesium

Cesium, or with its more classical Latin spelling, *Caesium*, is a chemical element with; it has symbol Cs and atomic number 55. Contrary to what one might think that it is named after Julius Caesar, it is in fact named after the Latin word *caesius*, meaning "bluish grey".

Cesium has physical and chemical properties similar to those of Rubidium and potassium. We dealt with Rubidium in considerable detail in our recent Rubidium Primer.

Properties

The chemistry of Cesium is similar to that of other alkali metals, in particular Rubidium, the element above Cesium in the periodic table. It is a soft, silvery-golden alkali metal with a melting point of 28.5 °C, which makes it one of only five elemental metals that are liquid at or near room temperature.

It is pyrophoric and reacts with water (often very explosively). It is the least electronegative stable element. It has only one stable isotope, Cesium-133.

Of all elements that are solid at room temperature, Cesium is the softest: it has a hardness of Mohs 0.2. It is a very ductile, pale metal, which darkens in the presence of trace amounts of oxygen. When in the presence of mineral oil (where it is best kept during transport), it loses its metallic lustre and takes on a duller, grey appearance. It has a melting point of 28.5 °C (compared to 39 °C for Rubidium), making it one of the few elemental metals that are liquid near room temperature. Mercury is the only stable elemental metal with a known melting point lower than Cesium.

In addition, the metal has a rather low boiling point, 641 °C, the lowest of all stable metals other than mercury.

Cesium forms alloys with the other alkali metals, Gold, and Mercury (amalgams). It forms well-defined intermetallic compounds with Antimony, Gallium, Indium, and Thorium, which are photosensitive. It mixes with all the other alkali metals (except Lithium).

Occurrence

Cesium is a relatively rare element, estimated to average 3 parts per million in the Earth's crust. It is the 45th most abundant element and 36th among the metals. Cesium is 30 times less abundant than Rubidium, with which it is closely associated, chemically.

Some History

The German scientists Gustav Kirchhoff and Robert Bunsen discovered Cesium with their newly invented spectroscope.

In 1860, Robert Bunsen and Gustav Kirchhoff discovered Cesium in the mineral water from Dürkheim, Germany. Because of the bright blue lines in the emission spectrum, they derived the name from the Latin word *caesius*, meaning “bluish grey”. Cesium was the first element to be discovered with a spectroscope, which had been invented by Bunsen and Kirchhoff only a year previously.

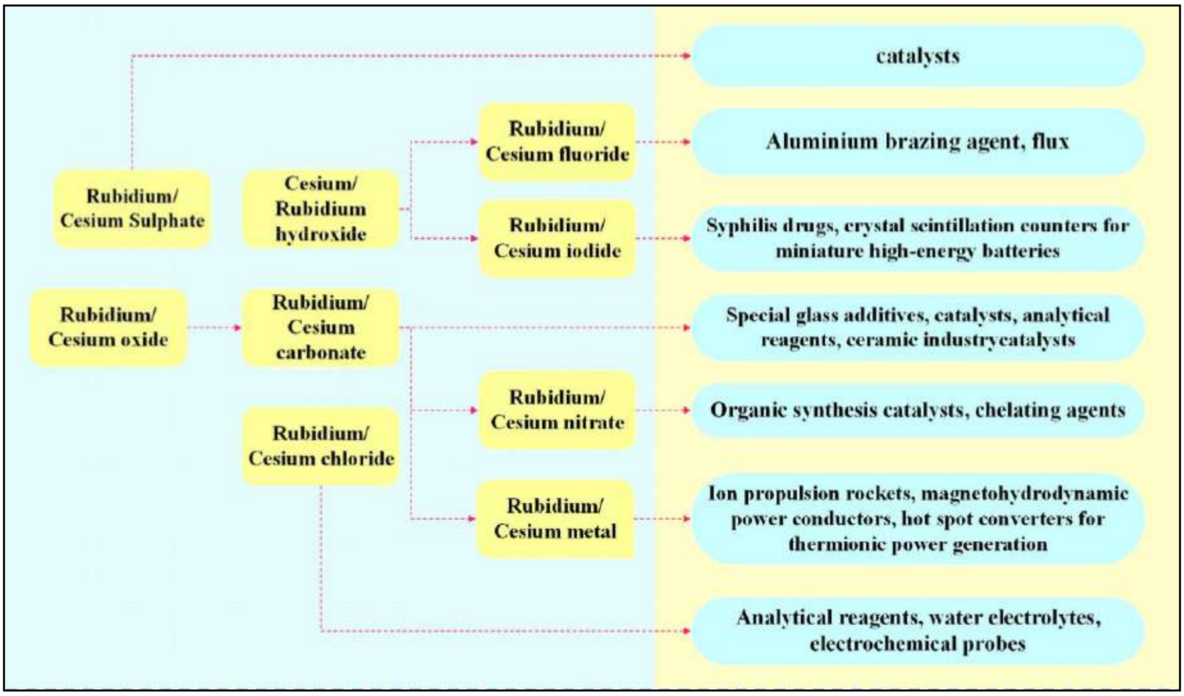
The pure metal was eventually isolated by the Swedish chemist Carl Setterberg while working on his doctorate with Kekulé and Bunsen. In 1882, he produced Cesium metal by electrolysing Cesium cyanide, avoiding the problems with the chloride.

Usage

The first small-scale applications for Cesium were as a "getter" in vacuum tubes and in photoelectric cells. Cesium is widely used in highly accurate atomic clocks. In 1967, the International System of Units began using a specific hyperfine transition of neutral Cesium-133 atoms to define the basic unit of time, the second. None of this significantly moved the dial, but mainly just provided an outlet for a by-product from Tantalum mining.

Then upon the scene appeared, since the 1990s, the use of Cesium, in Cesium formate, in drilling fluids mainly for applications in workover of high-pressure gas wells. This became Cesium´s largest demand source and the business was long dominated by a US company, Cabot Corp (NYSE: CBT) until 2020.

of positive ions in secondary ion mass spectrometry (SIMS).



Source: Niu, Yu et al.

The disparate range of other applications are in the production of electricity, in electronics, and in chemistry.

The radioactive isotope Cesium-137, a fission product, has a half-life of about 30 years. It is extracted from waste produced by nuclear reactors and has the largest atomic radius of all elements. It is used in medical applications, industrial gauges, and hydrology.

Non-radioactive Cesium compounds are only mildly toxic, but the pure metal's tendency to react explosively with water means that it is considered a hazardous material, and the radioisotopes present a significant health and environmental hazard.

Historically, the most important use for Cesium has been in research & development, primarily in chemical and electrical fields. Very few applications existed for Cesium until the 1920s, when it came into use in radio vacuum tubes, where it had two functions:

- as a getter, it removed excess oxygen after manufacture
- as a coating on the heated cathode, it increased the electrical conductivity.

Cesium was not recognized as a high-performance industrial metal until the 1950s.

Applications for non-radioactive Cesium included photoelectric cells, photomultiplier tubes, optical components of infrared spectrophotometers, catalysts for several organic reactions, crystals for scintillation counters, and in magnetohydrodynamic power generators. Cesium is also used as a source

Cesium Formate – Oil & Gas Exploration

The largest present-day use of non-radioactive Cesium is in Cesium formate drilling fluids for the extractive oil industry. Aqueous solutions of Cesium formate ($HCOO^{-}Cs^{+}$ - made by reacting Cesium hydroxide with formic acid) were developed in the mid-1990s for use as oil well drilling and completion fluids. The function of drilling fluid is to lubricate drill bits, to bring rock cuttings to the surface, and to maintain pressure on the formation during drilling of the well. Completion fluids assist the emplacement of control hardware after drilling but prior to production by maintaining the pressure.

The high density of the Cesium formate brine (up to 2.3 g/cm^3), coupled with the relatively benign nature of most Cesium compounds, reduces the requirement for toxic high-density suspended solids in the drilling fluid. This represented a significant technological, engineering and environmental advantage. Unlike the components of many other heavy liquids, Cesium formate is relatively environmentally friendly.

Cesium formate brine can be blended with potassium and sodium formates to decrease the density of the fluids to that of water (1.0 g/cm^3). Furthermore, it is biodegradable and may be recycled, which is important in view of its high cost. Alkali formates are safe to handle and do not damage the producing formation or downhole metals as corrosive alternative, high-density brines (such as zinc bromide $ZnBr_2$ solutions) sometimes do. They also require less cleanup and reduce disposal costs.

Atomic Clocks

The headline use of Cesium is in atomic clocks. The first accurate Cesium clock was built by Louis Essen in 1955 at the National Physical Laboratory in the UK. Cesium clocks have improved over the past half-century and are regarded as "the most accurate realization of a unit that mankind has yet achieved." The latest versions are accurate to about 1 second in 20 million years. The Cesium standard is the primary standard for standards-compliant time and frequency measurements. Cesium clocks regulate the timing of cell phone networks and the Internet (notably 5G).

Since 1967, the International System of Measurements has based the primary unit of time, the second, on the properties of Cesium. The 13th General Conference on Weights and Measures of 1967 defined a second as: "the duration of 9192631770 cycles of microwave light absorbed or emitted by the hyperfine transition of Cesium-133 atoms in their ground state undisturbed by external fields".

Electric power and electronics

Cesium vapour thermionic generators are low-power devices that convert heat energy to electrical energy. In the two-electrode vacuum tube converter, Cesium neutralizes the space charge near the cathode and enhances the current flow.

Cesium is also important for its photoemissive properties, converting light to electron flow. It is used in photoelectric cells because Cesium-based cathodes, such as the intermetallic compound K_2CsSb, have a low threshold voltage for emission of electrons. The range of photoemissive devices using Cesium include optical character recognition devices, photomultiplier tubes, and video camera tubes. Nevertheless, Germanium, Rubidium, Selenium, Silicon, Tellurium, and several other elements can be substituted for Cesium in photosensitive materials.

Cesium iodide (CsI), bromide (CsBr) and fluoride (CsF) crystals are employed for scintillators in scintillation counters widely used in mineral exploration and particle physics research to detect gamma and X-ray radiation. Cesium vapour is used in many common magnetometers.

The element is used as an internal standard in spectrophotometry. Like other alkali metals, Cesium has a great affinity for oxygen and, as mentioned earlier, is used as a "getter" in vacuum tubes. Other uses of the metal include high-energy lasers, vapour glow lamps, and vapour rectifiers.

Centrifugation fluids

The high density of the Cesium ion makes solutions of Cesium chloride, Cesium sulfate, and Cesium trifluoroacetate ($Cs(O2CCF_3)$) useful in molecular biology for density gradient ultracentrifugation. This technology is used primarily in the isolation of viral particles, subcellular organelles and fractions, and nucleic acids from biological samples.

Chemical and medical use

Relatively few chemical applications use Cesium. Doping with Cesium compounds enhances the effectiveness of several metal-ion catalysts for chemical synthesis, such as acrylic acid, anthraquinone, ethylene oxide, methanol, phthalic anhydride, styrene, methyl methacrylate monomers, and various olefins. It is also used in the catalytic conversion of sulfur dioxide into sulfur trioxide in the production of sulphuric acid.

Nuclear and isotope applications

Cesium-137 is a radioisotope commonly used as a gamma-emitter in industrial applications. Its advantages include a half-life of roughly 30 years, its availability from the nuclear fuel cycle, and having 137Ba as a stable end product. The high water solubility is a disadvantage which makes it incompatible with large pool irradiators for food and medical supplies.

It has been used in agriculture, cancer treatment, and the sterilization of food, sewage sludge, and surgical equipment.

Radioactive isotopes of Cesium in radiation devices were used in the medical field to treat certain types of cancer, but emergence of better alternatives and the use of water-soluble Cesium chloride in the sources, which could create wide-ranging contamination, gradually put some of these Cesium sources out of use.

Cesium-137 has been employed in a variety of industrial measurement gauges, including moisture, density, levelling, and thickness gauges.[99] It has also been used in well logging devices for measuring the electron density of the rock formations, which is analogous to the bulk density of the formations.

Other uses

Electrons beamed from an electron gun hit and ionize neutral fuel atoms; in a chamber surrounded by magnets, the positive ions are directed toward a negative grid that accelerates them. The force of the engine is created by expelling the ions from the rear at high velocity. On exiting, the positive ions are neutralized from another electron gun, ensuring that neither the ship nor the exhaust is electrically charged and are not attracted.

Cesium nitrate is used as an oxidizer and pyrotechnic colorant to burn silicon in infrared flares, such as the LUU-19 flare,[106] because it emits much of its light in the near infrared spectrum. Cesium compounds may have been used as fuel additives to reduce the radar signature of exhaust plumes in the Lockheed A-12 CIA reconnaissance aircraft.

Cesium and Rubidium have been added as a carbonate to glass because they reduce electrical conductivity and improve stability and durability of fibre optics and night vision devices. Cesium fluoride or Cesium aluminium fluoride are used in fluxes formulated for brazing aluminium alloys that contain magnesium.

Magnetohydrodynamic (MHD) power-generating systems were researched but failed to gain widespread acceptance. Cesium metal has also been considered as the working fluid in high-temperature Rankine cycle turboelectric generators.

Cesium salts have been evaluated as antishock reagents following the administration of arsenical drugs. Because of their effect on heart rhythms, however, they are less likely to be used than potassium or Rubidium salts. They have also been used to treat epilepsy.

Cesium-133 can be laser cooled and used to probe fundamental and technological problems in quantum physics. It has a particularly convenient Feshbach spectrum to enable studies of ultracold atoms requiring tunable interactions.

Pricing

The most recent commentary of the USGS on Cesium that we could find was from 2022.

The United States was 100% net import reliant for its Cesium needs. In 2021, one company offered 1-gram ampoules of 99.8% (metal basis) Cesium for $69.90, a 7.2% increase from $65.20 in 2020, and 99.98% (metal basis) Cesium for $88.90, a 5.0% increase from $84.70 in 2020. In 2021, the prices for 50 grams of 99.9% (metal basis) Cesium acetate, Cesium bromide, Cesium carbonate, Cesium chloride, and Cesium iodide were $131.20, $75.90, $110.20, $112.00, and $127.60, respectively, with increases ranging from 4.1% to 9.3% from prices in 2020.

The price for a Cesium-plasma standard solution (10,000 micrograms per milliliter) was $78.60 for 50 milliliters and $120.00 for 100 milliliters, and the price for 25 grams of Cesium formate, 98% (metal basis), was $42.60. In 2020, the price for a Cesium-plasma standard solution (10,000 micrograms per milliliter) was $77.80 for 50 milliliters and $119.00 for 100 milliliters, and the price for 25 grams of Cesium formate, 98% (metal basis), was $41.40.

To put the Cesium formate price in context, it represented $1.656 mn per tonne.

Health Hazards

As mentioned earlier, Cesium metal is highly reactive and pyrophoric. It ignites spontaneously in air, and reacts explosively with water even at low temperatures, more so than the other alkali metals. It reacts with ice at temperatures as low as −116 °C. Because of this high reactivity, Cesium metal is classified as a hazardous material. It is stored and shipped in dry, saturated hydrocarbons such as mineral oil. It can be handled only under inert gas, such as Argon.

Cesium can be stored in vacuum-sealed borosilicate glass ampoules. In quantities of more than about 100 grams, Cesium is shipped in hermetically-sealed, stainless steel containers.

The isotopes 134 and 137 are present in the biosphere in small amounts from human activities, differing by location. RadioCesium does not accumulate in the body as readily as other fission products (such as radioiodine and radiostrontium). About 10% of absorbed radioCesium washes out of the body relatively quickly in sweat and urine. The remaining 90% has a biological half-life between 50 and 150 days. RadioCesium follows potassium and tends to accumulate in plant tissues, including fruits and vegetables

Plants vary widely in the absorption of Cesium, sometimes displaying great resistance to it. It is also well-documented that mushrooms from contaminated forests accumulate radioCesium (Cesium-137) in the fungal sporocarps. Accumulation of Cesium-137 in lakes has been a great concern after the Chernobyl disaster. Experiments with dogs showed that a single dose of 3.8 millicuries per kilogram is lethal within three weeks and smaller amounts may cause infertility and cancer.

The portion of the total radiation dose (in air) contributed by each isotope plotted against time after the Chernobyl disaster. Cesium-137 became the primary source of radiation about 200 days after the accident.

Non-radioactive Cesium compounds are only mildly toxic, and non-radioactive Cesium is not a significant environmental hazard. Because biochemical processes can confuse and substitute Cesium with potassium, excess Cesium can lead to hypokalemia, arrhythmia, and acute cardiac arrest, but such amounts would not ordinarily be encountered in natural sources.

The International Atomic Energy Agency and other sources have warned that radioactive materials, such as Cesium-137, could be used in radiological dispersion devices, or "dirty bombs". For those with longer memories, the third series or the thriller series “24” centred around the deployment and threat of a Cesium “dirty bomb”.

Cesium is to Pollucite…

Cesium has, in the past, been extracted in considerable amounts from the Cesium-rich mineral pollucite, commercial deposits of which were discovered in the USA (Maine, South Dakota), Sweden (Varutrask, an asset owned in recent times by ourselves), Namibia, ex-CIS states, and other countries.

…. as Rubidium is to Lepidolite

The main form of Cesium and Rubidium raw material for a long time has been lepidolites (or lithium micas). Lepidolites are complex aluminum silicates of lithium and Potassium in which a very small part of the alkali metals is preplaced by Rubidium and Cesium.

These lepidolites, along with small amounts of Rubidium and Cesium (about 0.5%), contain up to 4-5% lithium oxide. Lithium salts were the main product, while Rubidium and Cesium were byproducts.

Mining & Deposits

Due to its large ionic radius, Cesium is one of the "incompatible elements". During magma crystallization, Cesium is concentrated in the liquid phase and crystallizes last. Therefore, the largest deposits of Cesium are zone pegmatite ore bodies formed by this enrichment process. Because Cesium does not substitute for Potassium as readily as Rubidium does, the alkali evaporite minerals sylvite (KCl) and carnallite ($KMgCl\ 3{\cdot}6H_2O$) may contain only 0.002% Cesium. Consequently, Cesium is found in few minerals.

The only economically important ore for Cesium is pollucite Cs ($AlSi_2O_6$), which is found in a few places around the world in zoned pegmatites, associated with the more commercially important lithium minerals, lepidolite and petalite. Within the pegmatites, the large grain size and the strong separation of the minerals results in high-grade ore for mining.

The world's most significant and richest known source of Cesium was the Tanco Mine at Bernic Lake in Manitoba, Canada. It was estimated to contain 350,000 metric tons of pollucite ore, representing more than two-thirds of the world's reserve base. This number appears to be very old as the mine is viewed as largely finished off with only mineralisation left in the pillars.

Although the stoichiometric content of Cesium in pollucite is 42.6%, pure pollucite samples from the Bernic Lake mine contained only about 34% Cesium, while the average content is 24 wt%. Commercial pollucite contains more than 19% Cesium.

The Bikita pegmatite deposit in Zimbabwe is mined for its petalite, but it also contains a significant amount of pollucite. Another notable source of pollucite is/was in the Karibib Desert, Namibia.

In a quite stunning revelation, the USGS stated that consumption, import, and export data for Cesium have not been available since the late 1980s. Only a few thousand kilograms of Cesium chemicals were “thought” to be consumed in the United States every year.

In an (outdated) opinion of the USGS, at the present rate of world mine production of 5 to 10 metric tons per year, reserves would last for thousands of years. In light of the previous admission of ignorance by the USGS, the production statistic is akin to garbage in, garbage out.

Processing

As noted, the largest producers of Cesium have produced Rubidium as a by-product from pollucite.

We would estimate that this is now closer to zero due to (negative) developments at Bernic Lake (Manitoba) and Bikita (Zimbabwe). The latter is operating under Sinomines control but has been subject in recent months to rancour between the national government and the Chinese operators.

Several methods are available for separating Potassium, Rubidium, and Cesium. The fractional crystallization of a Rubidium and Cesium alum yields, after 30 subsequent steps, pure Rubidium alum. Two other methods are reported, the chlorostannate process and the ferrocyanide process.

Technological difficulties, as well as the small scale of production, determine the high cost of Cesium and Rubidium compounds and, consequently, metals. On the other hand, the high cost of materials, as well as the complex technique of working with metallic Cesium and Rubidium, are the main obstacles to the widespread use of Cesium- and Rubidium-based materials.

The extraction and further production of Cesium and Rubidium has developed due to the greatly increased use of these metals in various fields of application. Unlike Rubidium, Cesium has its own mineral, pollucite, which forms clusters of industrial importance in nature. Rubidium is a dispersed element, its minerals have not been found in nature, therefore, the ore technology of Rubidium does not exist.

Creating Concentrates

Mining and refining pollucite ore is a selective process and is conducted on a smaller scale than for most other metals. The ore is crushed, hand-sorted, but not usually concentrated, and then ground. Cesium is then extracted from pollucite primarily by three methods: acid digestion, alkaline decomposition, and direct reduction.

In the acid digestion, the silicate pollucite rock is dissolved with strong acids, such as hydrochloric (HCl), sulphuric (H_2SO_4), hydrobromic (HBr), or hydrofluoric (HF) acids. With hydrochloric acid, a mixture of soluble chlorides is produced, and the insoluble chloride double salts of Cesium are precipitated as Cesium antimony chloride (Cs_4SbCl_7), Cesium iodine chloride (Cs_2ICl), or Cesium hexachlorocerate (Cs2(CeCl6)). After separation, the pure precipitated double salt is decomposed, and pure CsCl is precipitated by evaporating the water.

The sulphuric acid method yields the insoluble double salt directly as Cesium alum ($CsAl(SO_4)2\cdot12H_2O$). The aluminium sulfate component is converted to insoluble aluminium oxide by roasting the alum with carbon, and the resulting product is leached with water to yield a Cs_2SO_4 solution.

Roasting pollucite with calcium carbonate and calcium chloride yields insoluble calcium silicates and soluble Cesium chloride. Leaching with water or dilute ammonia (NH_4OH) yields a dilute chloride (CsCl) solution. This solution can be evaporated to produce Cesium chloride or transformed into Cesium alum or Cesium carbonate. Though not commercially feasible, the ore can be directly reduced with potassium, sodium, or calcium in vacuum to produce Cesium metal directly.

The primary smaller-scale commercial compounds of Cesium are Cesium chloride and nitrate.

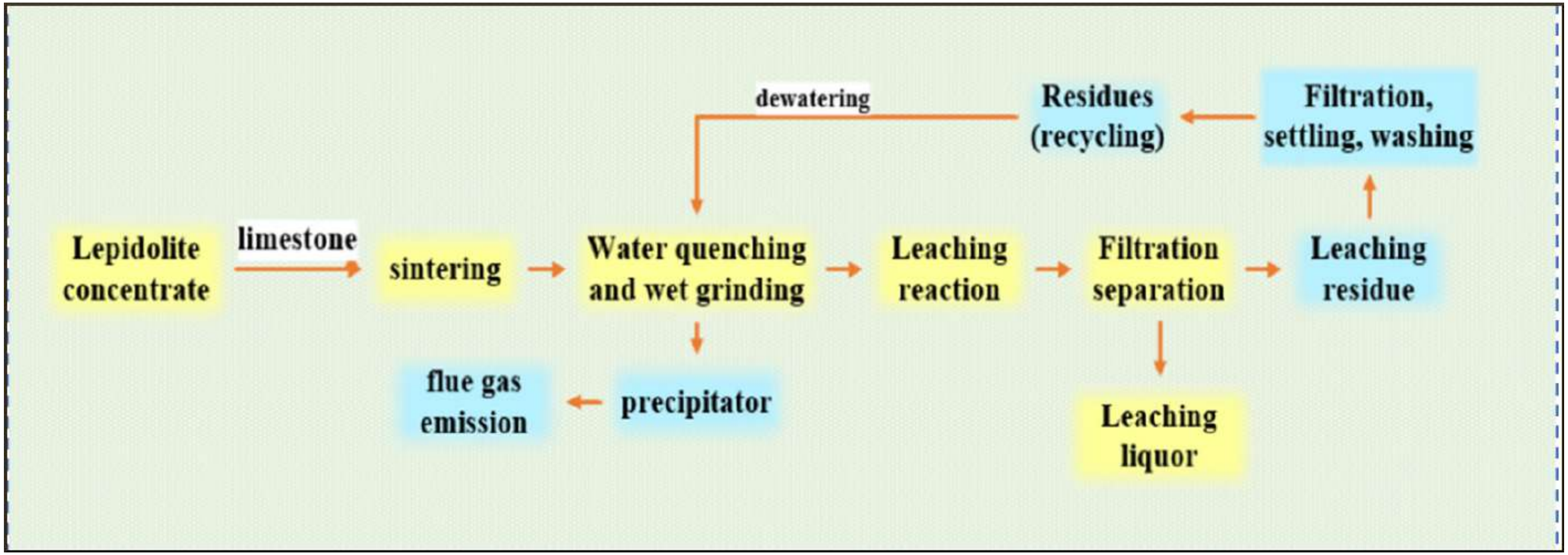
Alternatively, Cesium metal may be obtained from the purified compounds derived from the ore. Cesium chloride and the other Cesium halides can be reduced at 700 to 800 °C (1,292 to 1,472 °F) with calcium or barium, and Cesium metal distilled from the result. In the same way, the aluminate, carbonate, or hydroxide may be reduced by magnesium.

Processing of lepidolite. When processing spodumene and other lithium silicate minerals, it is necessary to take into account the possibility of associated extraction of Rubidium and Cesium, even in cases where they are present not in the main minerals, but in the accompanying minerals of industrial concentrates. It is all the more important to simultaneously extract Rubidium and Cesium from lepidolite, the richest joint source of raw materials.

Methods for extracting Cesium and Rubidium from lepidolite include those based on decomposition by sulphuric acid with its mixtures, as well as fusion and sintering methods. During acid decomposition, Rubidium and Cesium always pass into solution. Acid decomposition is designed to produce solutions of sulfates of alkaline elements. Alum is converted to chlorides through carbonates, and then Rubidium and Cesium are precipitated as chlorostannates, chloroplumbates, and other ways.

Obtaining pure individual salts of Cesium and Rubidium

During the processing of pollucite, lithium and Potassium minerals, radioactive waste and other raw materials, Rubidium-Cesium, Cesium-Rubidium and Rubidium-Potassium concentrates are obtained in the form of alum, chlorides, sulfates, carbonates and other salts. Such concentrates contain impurities of K, Na, Mg, Ca, Si, Al, Fe, Cr, Ti and other elements. Of these, Potassium is the closest in chemical properties to Rubidium and Cesium, so their separation is the most difficult problem in the technology of obtaining pure Rubidium and Cesium salts.



Source: Niu, Yu et al.

Several technological processes have been proposed for the separation of Potassium, Rubidium and Cesium, using slight differences in the conditions of formation and in the physico-chemical properties of some of their simple and especially complex salts: fractionated crystallization, precipitation, ion exchange chromatography, extraction. These processes are unequal for obtaining pure salts and substances of high purity.

Ion exchange chromatography and ion exchange sorption

Obtaining pure Rubidium and Cesium salts on an industrial scale is fundamentally possible using both classical chromatography (i.e. purely adsorption processes) and ion exchange chromatography, in which organic and inorganic ionites are used instead of adsorbents.

Chromatographic purification of Rubidium and Cesium salts, with its relative simplicity, low labor intensity and cyclicity, has one significant drawback: as a result, more dilute solutions are obtained than the initial ones. Dilution involves significant energy costs for evaporation of solutions and the need for large production capacities, and all this dramatically reduces the economic advantages obtained from the use of resins.

Extraction

Due to the fact that alkali metal ions in solutions are highly hydrated, and their ability to form complex compounds with organic citations is limited, the use of extraction for the concentration and separation of Rubidium and Cesium encounters significant difficulties.

As the ability of alkali metals to form complex compounds with organic ligands is rather limited, it should not be surprising that the extraction separation of Potassium, Rubidium and Cesium in the liquid—liquid system has been poorly studied.

The most effective extractants for the extraction and separation of alkaline elements are phenols.

In addition to widely used separation methods, Rubidium technology also uses unique technological techniques based on different volatility, such as Rubidium, Potassium and Cesium chlorides at high temperatures under vacuum. Ultrafiltration and a cascade of reverse osmotic membranes can be used to separate Rubidium and Cesium.

Recycling

The largest usage of Cesium is in Cesium formate brines. These are typically rented/leased by oil & gas exploration clients. After completion of the well, the used Cesium formate brine is returned and reprocessed for subsequent drilling operations. Cesium formate brines are recycled, recovering nearly 85% of the brines for recycling to be reprocessed for further use. This gives us the useful statistic though of 15% wastage on each go-around by a leasing client of Sinomines, implying that, ceteris paribus, over a relatively short period of time the entire stock of Sinomines will be degraded and lost unless replenished by new Cesium mined or discovered.

The Big Question….

Cesium and Rubidium are close in the Periodic Table and even closer in real life in their attributes.

…. Well, at least for us. As the chemical and physical properties of Rubidium are so similar to those of Cesium that the two elements are often used together or interchangeably in many uses, which begs the question as to whether Rubidium could play any role in the space that Cesium so dominates (and is so strategic) i.e. high-pressure gas well workovers. Rubidium formate exists but is used for other purposes. We have read nowhere of Rubidium's use in gas-wells. Is this because it is unsuitable? Or is it because Cesium (until recently) has been more available (under Cabot's, then Sinomines´, market domination) that thought was not applied to Rubidium being used in workovers?

In most shared applications, Cesium, which is more readily available and at times somewhat cheaper, has been used in preference to Rubidium. But drillers are clearly unhappy with the leasing model that dominates the Cesium formate market.

Conclusion

The ultimate irony of Cesium, the mineral that the US government delivered from almost total US control to total Chinese domination as recently as 2019 is now on the US's critical minerals register. *Sic transit gloria mundi.*

As with so much else in the critical minerals space the sound you hear is the flapping of gums rather than the sound of pneumatic drills. Mining the market (or the voters) takes precedent over mining the minerals.

It is clear that the US government allowing the sale of Cabot's division was a major mistake of epic strategic proportions. While the transaction cannot be reversed (as almost all the assets were outside the US anyway) there is scope for an incipient producer of Rubidium "ore" to create a value-added operation and play to the *Zeitgeist* of strategic positioning in a critical mineral. This would preclude sale of finished products to China but would conversely potentially bring a producer "most favoured status, exclusive access to markets and additionally attract funding for filling the strategic gap presented by Sinomines being effectively *persona non grata* in the US and elsewhere.

Finally, we would note that it appears the most attractive option for a Cesium or Rubidium miner is to enter the downstream and effectively become (and ensure) its own offtake.

The parties with the most incentive to enter this space are in fact the major oil drillers. An interesting side note to the Taron deposit is that it was originally evolved by Schlumberger. They were not wrong in pursuing it, only wrong in desisting.

Cesium remains an obscure object of desire. There is scope to break the iron grip of China (read Sinomines) on the mineral. There are some brave souls in the junior mining space talking the talk, but will they walk the walk?

As we usually say at the end of these reviews, time will tell.

References:

Extraction of Rubidium and Cesium from a Variety of Resources: A Review - Heyue Niu, Mingming Yu, Yusufujiang Mubula, Ling Zeng, Kun Xu, Zhehan Zhu and Guichun He in Materials.

Appendix I:

US Negligence & the Rise of Sinomines

Making America Dependent Again

We have oft noted the fact that the one metal that the US totally dominates in both the mining and processing is Beryllium. However, there is (or rather was) another mineral where the US totally dominated (through ownership) of the processing thereof. And that metal was Cesium. The biggest application for the element is the production of Cesium Formate a very high value input to oil & gas drilling for lubricating brines.

It might be recalled that we pointed out at the time that the US government had made a grave mistake in allowing Cabot Corp, the specialty chemicals group, to sell its Specialty Fluids division, which essentially controlled the world's stock of Cesium above ground, to Sinomines in a particularly serious own-goal in the midst of all the gum-flapping in Washington about Chinese domination of strategic minerals. In this Appendix we shall look at the dynamics of this transaction and Sinomines grip on the mineral.

Bernic Lake

Bernic Lake, historically the world's major source of Cesium, was long held by Tanco, a subsidiary of the US-based chemical major, Cabot Corp. However, Cabot sold its Specialty Fluids division (its main product being Cesium Formate, for high-pressure gas-well workovers) to Sinomine in a controversial transaction in 2019. Part of the logic of the sale was that Bernic Lake was effectively past its end of mine life and thus that there would be no more additions to the Cesium inventory of Cabot's division (where Cesium Formate is leased, rather than sold) to drillers. It was said that Sinomine were going to try and extract further material from tailings and stockpiles at site. Our source of intelligence on this mine (a veteran pegmatite geo who lives on a road leading to the old mine) says there has been no evidence that they have been able to process material from the "scrapings" left at the mine.

As already noted, most of the mined Cesium (as salts) is directly converted into Cesium formate ($HCOO^{-}Cs^{+}$) for applications such as oil drilling. To supply the developing market, Cabot Corporation built a production plant in 1997 at the Tanco mine near Bernic Lake in Manitoba, with a capacity of

12,000 barrels (1,900 m^3) per year of Cesium formate solution.

The Annals of Infamy?

Until last December of 2019, the world's biggest player with a sweeping dominance was Cabot Corp's Specialty Fluids division. Then in a stroke of a pen and the passing of a cheque this asset flipped from the US to China without so much as a batted eyelid or inflammatory tweet from Washington.

To put it bluntly we were stunned. This flew entirely in the face of M.A.G.A. mouthing and put US users of Cesium formate in an invidious position of being entirely dependent upon the good graces of Sinomine, the new owners, going forward. Ourselves, and a few other souls, noted this development with dismay. The oil & gas industry was silent though. One might imagine they didn't care, or one might more correctly surmise that they decided they shouldn't rock the boat or they might find themselves off Sinomine's client list.

We would sustain that Cabot Corp had the right to sell its divisions when it so chooses but that it did NOT have the right to sell to whoever, when it has long been allowed to enjoy a position of market dominance. Even in Australia, where supine acceptance of Chinese "creep' is long-established, the Foreign Investment Review Board (FIRB) would have had to put such a deal under the microscope, but in the US clearly it has just been waved through.

Australia has some more relevance here than just as a counterpoint. Cabot used as a rationale for its sale that it's long-established Tanco Mine in Manitoba, from which it produced the pollucite that Cesium is made from, was at its end of mine life. This was true but seemingly Cabot had been resting on its laurels here (something we would also accuse Materion of in the Beryllium space). How much effort had Cabot put into finding and developing a new source? Instead, it had done an offtake deal with an Australian company, Pioneer Resources (PIO.ax) which had just developed a pollucite mine in Western Australia (for more details see Appendix III).

Thus, Cabot's rationale was that the US dominance of Cesium should be abandoned because it didn't control a mine anymore. The solution might have been to buy Pioneer… but hey-ho.

Bikita – Cornering the Market

In early 2022, the Bikita Minerals lithium mine, which has been in operation since around 1950 and is located in the Bikita hills of Masvingo province in Zimbabwe, was acquired by Sinomine for US$180mn. The Bikita mine is a storied Lithium operation in Zimbabwe. In recent years it was viewed as being the private fiefdom of a particular minister in the government, who reputedly cut deals with the Chinese for his benefit. The product flow from this mine is Lithium and Cesium but it is reported to also produce Rubidium. The USGS claimed that the Bikita mine was depleted of pollucite ore reserves in 2018. We would not be so eager to accept this claim.

However, a ban on export of Lithium ores from Zimbabwe has been in place since late 2023 and reports in Mining Journal indicate that as much as 2 million tonnes of Lepidolite ore may have built up, awaiting export. If true this might indicate that the party in the government that vended Bikita to the Chinese may not have rewarded all who needed rewarding. Moreover, the rationale that Lithium ores should be upgraded in-country presents a major challenge for the Chinese with their attitude that all value-added should drop off at the processing facilities in the “mothership” (i.e. onshore China).

In late June of 2024, Sinomines launched a US$200mn project to build a lithium plant and expand existing operations at the Bikita Minerals lithium mine in Zimbabwe.

The Bikita mine predominantly produces petalite, a lithium mineral that is used in the ceramic and glass industries, but is also known to produce Cesium, for which Sinomines has been an eager buyer.

The new investment will allow the mine to produce spodumene which is more useful for battery production than petalite.

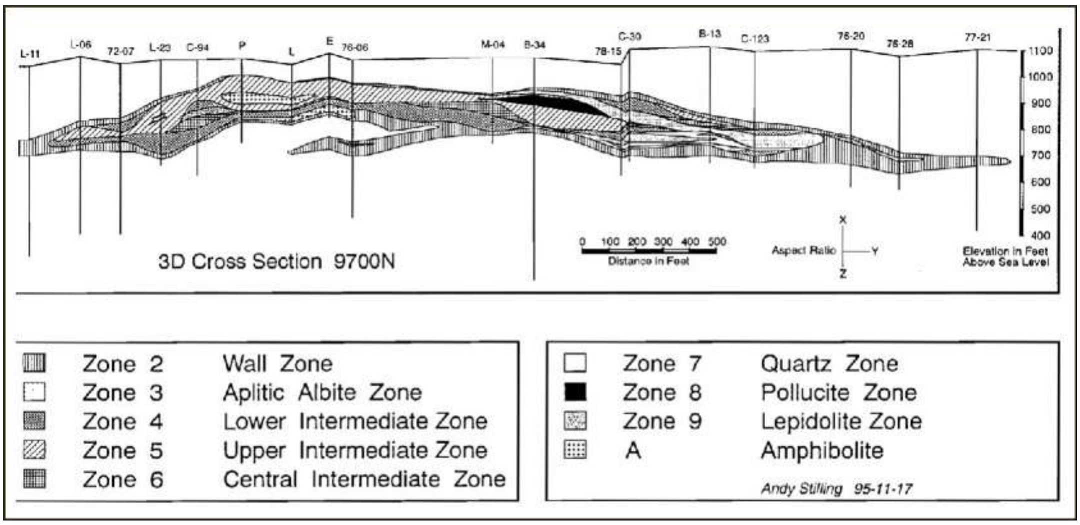
The investment is also expected to position the oft-overlooked country as a major player in the battery mineral supply chain while bringing value growth to the manufacturing industry chain.

With the new investment, Sinomines planned to increase the mining and processing capacity at the Bikita mine to 1.2mn tpa by the end of this year and intends to build a new ore production line with a 2mn tpa capacity. Though how much value Sinomines will allow to stay in Zimbabwe is debatable.

From all this, the market interprets the Sinomine move as a Lithium play and, by and large, it is, but there are easier places to play for that mineral than Zimbabwe. Unless somebody comes up with something new, no other places for the Chinese or anybody else to lay their hands on any Cesium.

Tanco Redux

One of the more problematical moves by Sinomine was a plan to revive the Tanco Mine to mine Cesium and tantalum from Bernic Lake using open-pit methods, which involves draining the lake and taking out the mineralized pillars of the former mine.



This plan surfaced in 2023 and was reported by the CBC, quoting one of the authors of this report.

The plan was to drain "parts" of Bernic Lake for open-pit mining. This ran into environmental opposition regarding concerns about sediment contamination of the Bird River as well as consent needs from the Sagkeeng First Nation.

Bernic lake is approximately 5kms long and around 1km wide at its broadest point.

Why should Canada allow a critical minerals deposit representing the **ONLY** Western source of Cesium to be redeveloped by a Chinese entity (that would not be allowed to buy it today) and which Canada was seemingly not consulted on when it was sold in 2019?

In Namibia

Sinomine acquired the Tsumeb Mining Holding's facilities in 2010 from Dundee Precious Metals. This was supposedly part of a strategy to develop Cesium and Germanium production at the historic Tsumeb smelter in Namibia, leveraging the rich mineral deposits from the famous Tsumeb mine for specialized alkali metal salts, transforming the site's focus beyond just copper.

The Tsumeb mine, commercially mined until 1996, was in its heyday a major producer of Lead, copper, zinc, silver, and "rare elements".

We had been intrigued by past references of the USGS to Cesium production out of Namibia, but the source was not stated, but we believed it was the Tsumeb mine.

Cornered?

Sinomines has a problem in that they are now quite severely circumscribed in the field of international action. New rules in Canada would block them from actions relating to strategic assets controlled by Canadian companies (they would almost certainly not be allowed to acquire Tanco today, no matter that it was a supposedly expired mine).

Onshore assets in Australia would be precluded from their reach also. It is unlikely they would get approval for mining acquisitions or even offtakes in Europe.

The US has been exercising suasion in Latin America also with regard to strategic metal moves by Chinese companies. This leaves Africa as one of the last free fields of action open to the Chinese in strategic/critical metals.

Appendix II:

Names to Conjure With

The Flurry in the Promotorial Classes

The mining equities space has seen an upsurge of companies claiming to have Cesium in their mineralisations. The managements of some of these companies know little to nothing about Cesium and the term “critical mineral” is thrown about with gusto and seemingly lacking awareness that the mineral is NOT on any critical minerals list because it is so little used and certainly the world would not stop turning (and guns would not stop firing) if no Cesium was ever produced again.

This has not stopped the metal/mineral from being co-opted into the hallowed realms of criticality.

In this section we will look at the current claimants to be developing or holding Cesium deposits, excepting Sinomines (dealt with in Appendix I) and Essential Metals (dealt with in Appendix III).

Power Metals (TSX-V: PWM $0.90 | OTCQB: PWRMF $0.63 | FRANKFURT: OAA1)

Maybe reflective of the lack of knowledge of the space the most “advanced” promoter of matters Cesium is Power Metals and yet on its website its claims the Bitika (sic) in Zimbabwe is not producing, when it is the opposite, the Tanco is producing (which it is not) and that Sinclair is not currently producing (maybe because it is viewed as mined out). As noted earlier “mined out” is also a sign that could be put up at the entrance to Tanco. Companies do themselves no great service when they highlight competitors that are not even in the game. “Know thy market” should be the mantra in all metals, particularly one as obscure as Cesium.

Anyway, Power Metals is the loudest trumpet blower in the very small band of Cesium players.

The company´s Case Lake property, is and was primarily a Lithium target. It is located 80 km east of Cochrane, NE Ontario close to the Ontario-Quebec border. The Case Lake pegmatite swarm consists of six spodumene dykes: North, Main, South, East and Northeast Dykes on the Henry Dome and the West Joe Dyke on a new tonalite dome. Case Lake has the advantage of year-round road access.

In August 2018, Power Metals geologist discovered West Joe spodumene pegmatite, 790 m west of

Little Joe Lake, 1.6 km southwest of the western edge of the Main Dyke and 3.0 km southwest of the Northeast Dyke.

In addition to Lithium and Tantalum mineralization, West Joe Dyke also contains Cesium mineralization as shown by the presence of pollucite in drill core and exceptionally high-grade Cs intervals:

- 14.70 % Cs_2O over 1.0 m, 13.0 to 14.0 m in hole PWM-18-126
- 12.40 % Cs_2O over 1.0 m, 10.0 to 11.0 m in hole PWM-18-112
- 6.74 % Cs_2O over 5.0 m, 11.0 to 16.0 m in hole PWM-18-126

Power Metals claim that pollucite is rare in pegmatites in Ontario, as it has only been identified in five pegmatite localities in the province: Power Metals owned Case Lake, Tot Lake and Marko's pegmatites and two other localities.

In early June of 2025, the company announced a maiden Inferred Mineral Resource Estimate (MRE) at the West Joe dykes within the Case Lake Cesium Project. They posited that this was the "world's fourth only hard-rock Cesium resource".

Case Lake Cesium Project

0.1% Cs2O cut-off within pit

Category	Tonnes	Cs_2O %	$Li_2$2O %	Ta_2O_5 ppm	Cs_2O tonnes	$Li_2$2O tonnes	Ta_2O_5 tonnes
Inferred	13,000	2.4	1.3	460	330	180	6

The MRE covers just one of eight pollucite-bearing pegmatite dykes, based on 7,264 m of drilling from 113 drill holes conducted in 2018, 2022, and 2024.

At the time of releasing this MRE, the company reported a further exploration target of 11,000-15,000 tonnes of Cs_2O (produced by Snowden Optiro) identified at the West Joe dykes. Over and above this, management said that there were 17 untested targets with pollucite-bearing pegmatite dykes, outside of the West Joe dykes and within the Case Lake Cesium Project which "offer excellent potential to expand the resource profile".

Cascadero Copper

To say we know more about this stock than anyone else is an understatement as one of the authors of this report was the CEO of Cascadero Copper in 2020, when he was brought in the resolve and fractious and finally deficient situation after many years of use and abuse of the assets and shareholders by miscreant management. Proving to be recalcitrant, unreformed and oblivious to corporate governance, the CEO departed. The stock slumped back to *de minimis* levels and has remained there since.

Despite all this the company has a few gems in its portfolio, the relevant one here being Taron, which is the only standalone Cesium project with an extant resource, and indeed, a PEA.

Taron MRE

1,239 ppm Cs2O cut-off

Category	Tonnes	Cs_2O ppm	Cs_2O tonnes
Inferred	23.85	2,131	50,810

Taron is also interesting and novel in that it is a "geyser" deposit of Cesium rather than a pollucite deposit. There is supposedly one other such deposit and it is at Chabu in Southern Tibet.

The Taron deposit contains significant concentrates of Cesium in a complex oxidized mineral assemblage associated with iron-arsenic-aluminum-manganese-silica mineralization. The recovery of Cesium has been studied using sulfuric acid leaching with recovery of Cesium as alum. The waste solution from Cesium recovery is oxidized and neutralized to form stable iron - arsenate residues. The Cesium alum is further treated to form high purity Cesium hydroxide, which may be further processed to a range of Cesium salts, including Cesium formate.

International Lithium

International Lithium is a client of Hallgarten + Company and has been involved with proving up the MRE on its Raleigh Lake Rubidium project in Ontario.

In an interesting turn of events in early 2025, when International Lithium appeared at the court proceedings for the troubled Lepidico (LPD.ax) and was awarded its project in Namibia (that Lepidico had picked up through a merger with a company called Desert Lion in mid-2019).

Lepidico, a wannabe Lithium producer located in the Karibib Pegmatite Belt of Namibia, undoubtedly had ambitions as far as Cesium/Rubidium are concerned. The company has also signaled that it plans to develop processing facilities in the Middle East, with cheap energy being a drawcard.

In March of 2019, we had met with Lepidico at PDAC and were impressed with their grasp of the Cesium potential and their strategy to acquire the producing Alvarrões property in northeast Portugal from Grupo Mota. However, by late 2019, this had still not closed (possibly because Lepidico got sidetracked into buying Desert Lion in Namibia).

While Lithium was once deemed to be its primary target, Lepidico also signaled a desire to have Cesium, Potassium, and Rubidium as potential byproducts. Accordingly, we had added Lepidico to our Model Resources Portfolio and yet had found the Lepidico holding to be disappointing. The contrast with Pioneer, which we added to the Portfolio just as we dropped Lepidico which we ditched rather swiftly, was poignant.

Lepidico actually believed it was a Lithium play, when it clearly had potential as a Cesium play. Meanwhile Pioneer are still mouthing Lithium (for the cheap seats) but actually doing Cs for real.

There is mineral resource estimate for the Karibib project in Namibia, reporting 8.9mn metric tonnes of Measured and Indicated resources containing 0.23% Rubidium and 302 ppm of Cesium.

Patriot Battery Metals (TSX: PMET)

Least of the contenders, and a **SHORT** position in our Model Resources Portfolio, is Patriot Battery Metals, a one-time go-go stock in the Lithium space with its asset in the icy wastes of James Bay in northern Quebec.

The project, after a forelock-tugging name change to Shaakichiuwaanaan, remains primarily a Lithium project. Despite a CAD$69mn (US$48mn) investment from Volkswagen Group in January of 2025 to fund a feasibility study, the project remains unpronounceable, and in our humble opinion, likely uneconomic as an addition to North America´s Lithium needs. In our new form of instant dismissal, it is eminently "Surplus to Requirements" in an overcrowded Lithium space.

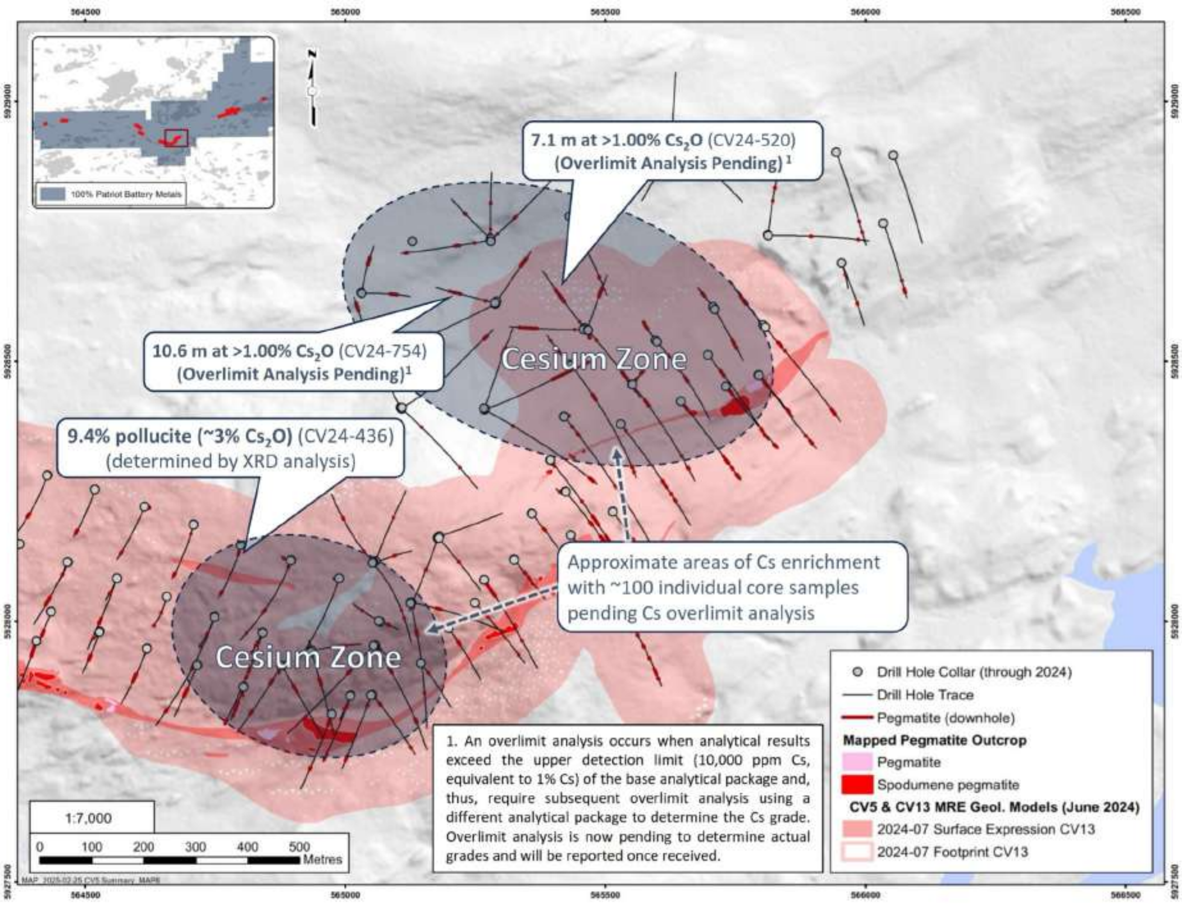
The Shaakichiuwaanaan Property hosts a consolidated MRE of 80.1mn tonnes at 1.44% Li_2O Indicated and 62.5mn tonnes at 1.31% Li_2O Inferred. The CV5 Spodumene Pegmatite, which forms the bulk of the MRE, is accessible year-round by all-season road and is situated approximately 14 km from a major hydroelectric powerline corridor. The CV13 Pegmatite is located <3 km along geological trend from the CV5 Pegmatite.

Having handed off the geological and block models for the CV5 Pegmatite to the Feasibility Study team, the technical team further reviewed its core assay dataset and identified multiple distinct areas of "considerable" Cesium enrichment (considerable being >1% Cs in their definition). These include the CV5 and CV12 pegmatites, however, the two largest zones are hosted by the CV13 Pegmatite.

Cesium results in drill hole and channel samples included:

- 10.4 m at 1.30% Cs2O, including 4.0 m at 2.02% Cs2O (CV23-117) at CV5
- 10.6 m at >1.00% Cs2O (CV24-754) at CV13
- 7.1 m at >1.00% Cs2O (CV24-520) at CV13
- 0.5 m at 9.58% Cs2O (Channel CH22-047) at CV12

In its release of early March of 2025, the company claimed that two distinct areas of Cesium enrichment have been identified at the CV13 pegmatite.



The principal and largest of the Cesium zones is coincident with the "high-grade" Lithium Vega Zone and can be traced in drill hole over an area of approximately 600 m x 400 m, ranging in thickness from 1-2m to at least 10 m (core length).

The second zone is associated with the apex of the structural flexure at CV13 and is estimated through drilling to be at least ~250 m x 50 m in area and up to several metres thick.

The problem here is that if the Lithium is never mined (in part due to the outlandish location) then will the pollucite be exploited? The company has shown itself to be so promotional that it is at the other end of the spectrum from Essential Metals with led with production and put Lithium in the backseat.

Appendix III:

Essential – Lessons in Opportunity & Limitations

The Background

When it first came to our attention in the middle of last decade the Sinclair Mine in Western Australia was controlled by the then called Pioneer Resources-ASX:PIO) later renamed Essential Metals (ASX:ESS).

For the brief few shining moments in which Essential Metals was a Cesium producer from the Sinclair deposit on its Pioneer Dome project, its main (or maybe only) buyer was China's Sinomine Resource Group, sometimes referred to as China Mineral Resources.

The Sinclair Pegmatite at Pioneer's Dome Project is classed as a complex Lithium-Cesium-Tantalum (LCT) pegmatite due to its mineral assemblage and degree of mineral fractionation. This has resulted in the formation of a suite of monomineralic phases that include Cesium-bearing pollucite, Lithium-bearing petalite and lepidolite, Potassium feldspar and silica.

The company had an offtake deal inked with Cabot Corp (NYSE:CBT) that then ruled the Cesium space with a total dominance).

With the offtake deal with Cabot squared away, Pioneer moved to production only to find the client sold off to the Chinese. However, this did not reduce Sinomine's need for the output from Pioneer's Sinclair Mine.

The Producing Years (well, months)

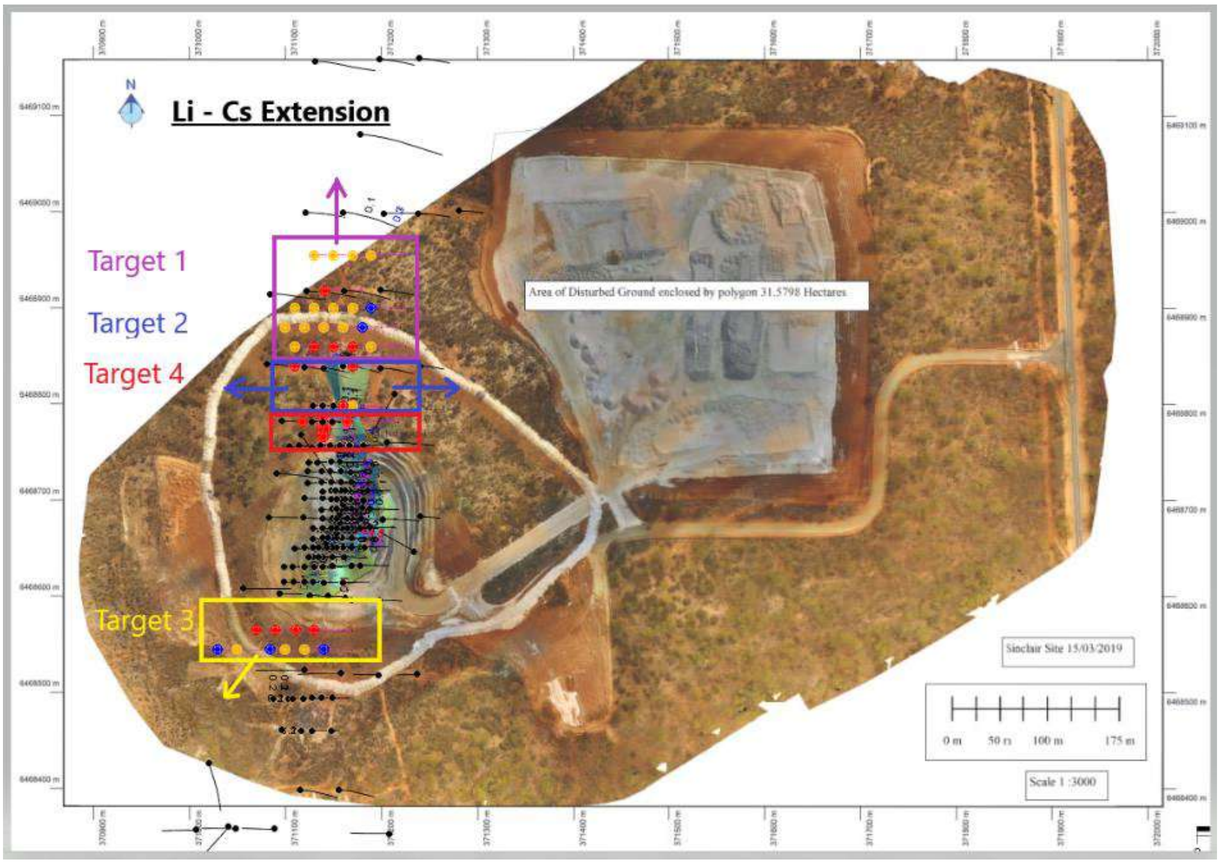
The Stage 1 open pit mining operation was completed on budget in January of XXX. Approximately 19,000 tonnes of crushed pollucite ore with an average grade of 9.1% Cs_2O (Cesium Oxide) was stockpiled with a small quantity of residual low-grade ore also stockpiled.

In its results for 1H19 (six months to 30 June 2019) pollucite sales from Sinclair Mine totalled AUD$10.5mn (US$7.5mn), with AUD$3.8mn received in cash and A$6.7mn (US$4.8mn) applied to fully repay a project loan (from Cabot's former Specialty Fluids division).

Pioneer also let on that, following discussions in July with the offtaker, the company expected to sell a further US$6.7mn (around AUD$9.5mn at the then exchange rate) of pollucite to be 100% settled in cash by the end December 2019.

What was missing was volume (and contained minerals) information because that would have given us a snapshot of what the Cesium was actually worth to Sinomines. However the sales numbers from what was presumably not enormous volumes provides a hint that Sinomines were prepared to pay up to get their hands on the desired material.

Below can be seen the mine site and drill work.

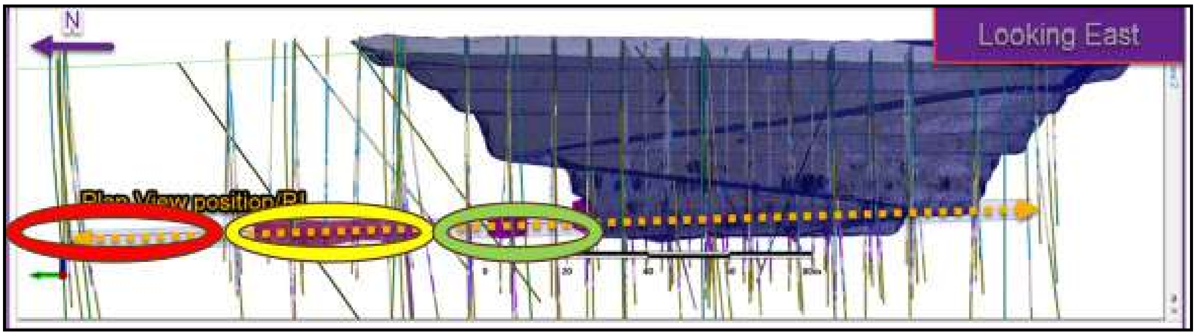


On the exploration front, the company discovered a new spodumene-bearing pegmatite system at Dome North prospect at the project. Rock chip assay results were grading up to 3.7% Li_2O. High-grade spodumene mineralisation was identified within two pegmatite outcrops with a combined current strike length exceeding of 500m. A maiden drilling program is set to commence in August.

Essential Cesium

We remained somewhat torn on Essential Metals as it hovered between being a rather unexciting Lithium play and being the only listed company to have been a newcomer to the Cesium production scene in the current century (or more).

The problem for all putative Cesium producers is that pollucite (the host mineral) tends to appear in pods and that these pods vary in size with the LCT pegmatites that host them and they can peter out or just be ornery to uncover. The only thing that works is drilling which might randomly intersect a pod or more concerted mining of the pegmatite for Lithium with the Cesium being chance “icing on the cake” should a pod be stumbled upon.



The cross-section above represents drilling done at the Sinclair deposit in 2018-19 with the three Cesium target zones along strike shown. As things turned out, only the yellow area proved to have pollucite intersections promising Cesium potential.

Essential Metals completed the mining and shipments of all economically recoverable pollucite ore in 2019. It is worth noting that Sinomine was the exclusive recipient of the Sinclair mine’s pollucite output through a deal that was a legacy of an arrangement supposedly made by Cabot, pre-sale.

At the time we took this “resource exhaustion” statement with a degree of scepticism. The Chinese, in particular, have a vested interest in obfuscating the state of the supply situation in both Rubidium and Cesium. The fact that Chinese interests then made a foray to take over Essential might indicate otherwise.

The End Game

At its most productive moment we speculated that the next logical step would have been the Chinese moving on Pioneer. This would have provided an interesting moment when we find out whether the

FIRB is more on the ball than the US government had shown itself to be in protecting (the US's) strategic interests by blocking a Chinese acquisition of this mine.

Essential Metals was successfully taken over by Develop Global (ASX: DVP) in late 2023, following an earlier rejected bid from an IGO/Tianqi JV site. After shareholders voted down the Tianqi/IGO offer, Mineral Resources (ASX: MIN) acquired a stake, leading to Develop Global's recommended offer of one Develop share for every 6.18 Essential shares, valuing the target at around AUD$150m, which closed in October 2023.

The timeline was:

- Early 2023: A joint bid by Tianqi Lithium Energy Australia (TLEA) site (Tianqi & IGO) for AUD$136m was rejected by Essential shareholders, partly due to Mineral Resources' intervention
- April 2023: Mineral Resources acquired a significant stake in Essential Metals.
- July 2023: Develop Global, backed by Mineral Resources, made a binding takeover offer for Essential Metals
- October 2023: Essential shareholders approved the Develop Global offer, valuing Essential at roughly AUD$150-$152.6 million
- October 2023: The takeover by Develop Global was completed, with Essential shareholders receiving Develop shares, integrating Essential's Pioneer Dome lithium project into Develop's assets

There endeth the lesson…

Important disclosures

I, Christopher Ecclestone, hereby certify that the views expressed in this research report accurately reflect my personal views about the subject securities and issuers. I also certify that no part of my compensation was, is, or will be, directly or indirectly, related to the specific recommendations or view expressed in this research report.

Hallgarten's Equity Research rating system consists of LONG, SHORT and NEUTRAL recommendations. LONG suggests capital appreciation to our target price during the next twelve months, while SHORT suggests capital depreciation to our target price during the next twelve months. NEUTRAL denotes a stock that is not likely to provide outstanding performance in either direction during the next twelve months, or it is a stock that we do not wish to place a rating on at the present time. Information contained herein is based on sources that we believe to be reliable, but we do not guarantee their accuracy. Prices and opinions concerning the composition of market sectors included in this report reflect the judgments of this date and are subject to change without notice. This report is for information purposes only and is not intended as an offer to sell or as a solicitation to buy securities.

Hallgarten & Company acts as a strategic consultant to Summa Silver and as such is compensated for those services, but does not hold any stock in the company, nor has the right to hold any stock in the future.

Hallgarten & Company or persons associated do not own securities of the securities described herein and may not make purchases or sales within one month, before or after, the publication of this report. Hallgarten policy does not permit any analyst to own shares in any company that he/she covers. Additional information is available upon request.

Hallgarten & Company has acted as a strategic consultant to International Lithium and as such is/was compensated for those services but does not hold any stock in the company nor does it have the right to hold any stock in the future.

Web access at:

Research: www.hallgartenco.com