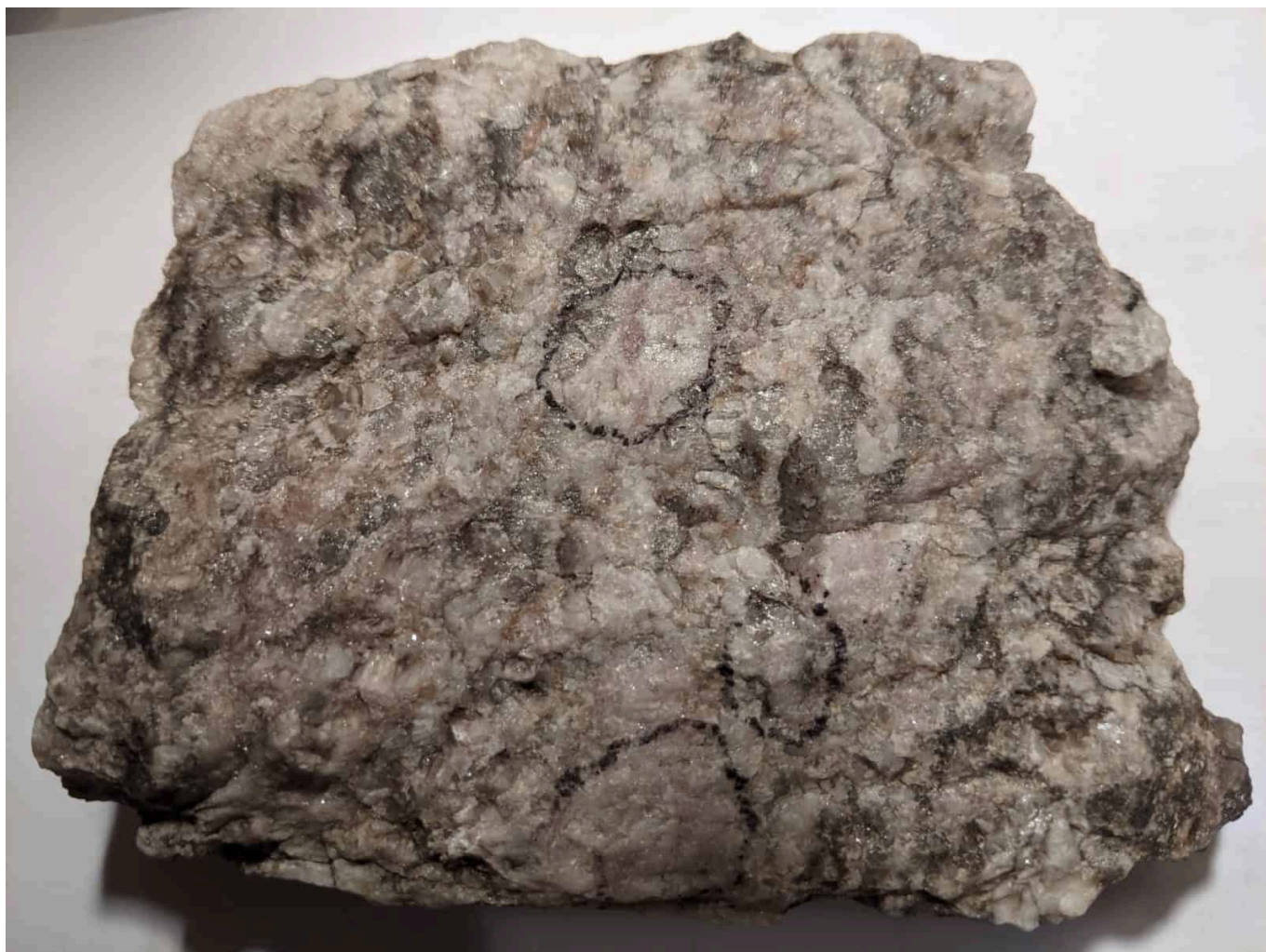


# Cesium, A Critical Metal and an Opportunity for Avalon Advanced Materials

As the only geologist who has seen and worked on the two largest known Cesium deposits in the world; the Tanco (Tantalum Mining Corporation of Canada) Lithium-Cesium-Tantalum ("LCT") Pegmatite Mine in Canada and the Taron Epithermal Cesium deposit in Argentina, and with 46 years of experience in rare element geology and markets, I was invited to share my knowledge and experience on the importance of Cesium with InvestorIntel readers.

Cesium (or Caesium) has mainly been recovered from the rare alumino-silicate mineral Pollucite ( $(\text{Cs,Na})_2\text{Al}_2\text{Si}_4\text{O}_{12}\cdot 2\text{H}_2\text{O}$ ), a zeolite mineral named after Pollux, one of the Gemini twins in Roman mythology. It is a little known alkali element with enormous potential for new applications. This is because, as the most electro-positive naturally found element (aside from synthesized Francium) in the periodic table, it forms exceptionally stable compounds. The best known example of which is a commercial application is Cesium formate, a high density fluid with the same viscosity as water but 2.2 times as dense. It is used in high pressure, high temperature deep oil & gas well drilling as a coolant and lubricant. It is eco-friendly and can be readily recycled.



Cesium compounds also have applications as catalysts in plastics and petroleum refining, medical isotopes, photo-emissive devices, experimental magneto-hydrodynamic electricity generation, high accuracy atomic clocks for 5G communications and GPS navigation systems, specialty glasses, ion-propulsion rocket motors, high-density alkaline batteries, and coatings for solar cells. As a dense medium, Cesium formate is also used in metallurgical testing and to separate DNA. It is well known for medical applications and artificially produced radioactive isotopes used in treating various types of cancers. It can also be used to sequester those radio-isotopes and other radioactive wastes.

During my years (1977 – 1983) working with Tanco at Bernic Lake, Manitoba, we would donate our pollucite at no charge to any research laboratory interested in finding other new uses for cesium which could create new market opportunities for

Tanco. We were sending large samples to Germany and they would mysteriously disappear; rumored to go behind the Iron Curtain through East Berlin. There was much speculation at that time that it was being tested by the Russians for mobile magneto-hydrodynamic power generation for beam weapons. Consequently, Tanco stopped these shipments at the request of the Canadian and U.S. governments.

In 1996-7 Tanco, having been bought by Cabot Corporation in 1993, commissioned a new Cesium formate plant designed to produce 500 barrels/day and subsequently expanded to 700 barrels/day for increased production including other cesium chemicals. By 2002 it was producing 8400 tonnes of Cesium formate product which were shipped in 1 cubic metre plastic totes containing about 1860 kgs.

In 2013, the Tanco underground mining operation began to experience falls of loose rock because of instability of the Mine's crown pillar. Because this part of the mine was under a lake, risk of a major collapse forced closure of Tanco's cesium underground mining operations. In 2019 Tanco was sold by Cabot Corp. to Sinomine Resource Group Co., Ltd. of Beijing, China ("Sinomine").

The Bikita Minerals' (PVT) pegmatite in Zimbabwe, the only other significant past producer of pollucite, did not process it but sold it as hand-sorted mineral concentrates. Albemarle in Langelsheim, Germany bought Bikita pollucite to make a host of cesium chemicals and recently, Tanco, as Sinomine, was buying it too. Sinomine now also controls Bikita's supply although Bikita's pollucite ore stockpiles are now largely exhausted. Pioneer Resources' small Sinclair pollucite deposit in Western Australia was commissioned in 2018 and was mined out by 2020. Its pollucite was sold to Tanco and hence Sinomine.

This leaves Avalon Advanced Materials Inc. (TSX: AVL | OTCQB: AVLNF) ("Avalon") as the only near term and potential producer

of pollucite in North America, from its Lilypad Cesium Project in Northwestern Ontario. The Lilypad area hosts a field of LCT pegmatite dykes containing significant pollucite mineralization. Other LCT pegmatite resources in many parts of the world, including Namibia and Afghanistan, would also have potential to recover pollucite and by-product cesium from other minerals such as the lithium mica, lepidolite.

The Taron Cesium deposit in NW Argentina hosts a significant and open cesium resource where the cesium is contained in a unique hydrated basic ferric arsenate mineral called pharmacosiderite,  $(K,Cs)Fe_4(AsO_4)_3(OH)_4 \cdot (6-7)H_2O$ , and like pollucite is another zeolite-type mineral. Recent work has patented a unique extraction process with promising economics to recover the cesium.

As cesium is not an exchange-traded commodity it is difficult to get price information on the various forms of cesium products, although being in very short supply. The best known cesium product was the Cesium formate produced at Tanco and was actually leased to drilling companies, but prices weren't reported. Oil drilling companies paid for using the Cesium formate and after it was recovered from drill holes, it was returned for rehabilitation, with the drilling company paying for any downhole losses.

Lepidico (ASX: LPD) is an Australian company looking at recovering cesium from their LCT pegmatite holdings in Namibia. Their JORC accredited Definitive Feasibility Study of 2020 showed Cesium formate having a value of \$42,900 USD / tonne. Other chemical forms of cesium currently in demand include cesium carbonate and cesium hydroxide, which are reportedly attracting prices of up to \$5,000 USD / kg in Asian markets because of scarcity of supply. Like other rare element commodities, product purity also impacts pricing as well as supply and demand.

An indication of Cesium markets is given by some reverse

engineering of the Tanco Cesium Formate production. When Tanco's Cesium formate plant opened, it had a nameplate capacity of 500 tonnes/year and then it expanded further to 700 tonnes/year. The first step on the way to producing cesium formate and other chemical compounds is the production of Cesium hydroxide. To that end, Tanco mined 205,180 tonnes at a feed grade of 13.27%. In turn, that would produce 272,274 tonnes of Cesium over 16 years or about 1063 tonnes a year for Cesium compounds.

Cesium has now been listed as a critical element by the United States and Canada; Tanco and its owner, Cabot Corp., once had control of the business. With China now in sole ownership of the world's supply of pollucite, the cesium markets may be stressed accordingly until a new source of cesium has been developed. It is a great opportunity for Canada to take advantage of the cesium resources at Avalon's Lilypad project.

A key next step toward creating a full supply chain in Canada would be to encourage more research and development on potential innovative new applications for cesium similar to what Tanco did with Cesium formate 25 years ago. There is a great potential for many new high technology applications of cesium which would enable new primary supply sources in Canada to start and grow into bigger businesses with the downstream value-added product opportunities.