

Lithium, Beryllium, and Cesium Occurrence in the San Diego County Pegmatite District

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Presented at the AGU Annual Meeting, December 2024 (Poster #V21B-3261)

Abstract

The pegmatites of San Diego County and adjacent areas are world famous for their highly-prized gemstones, such as tourmaline, topaz, and garnet. While the district is not typically thought of as a source of critical elements, it was at one time the primary source of lithium in the United States and has also been prospected as a source of beryllium and cesium. Here we present a survey of the history of critical element occurrence and production in the region, along with a new geochemical trace element study of the district. Quartz samples from 13 mines and prospects were analyzed by four-acid digestion and inductively coupled plasma mass spectrometry (ICP-MS), yielding lithium concentrations that vary by more than a factor of 30 across sites and cesium concentrations that vary by more than a factor of 300. The results for cesium in particular, and the relative dearth of historic exploration for it, suggest there may be previously unrecognized commercial potential in the region.

1. Introduction

The pegmatites of San Diego County and adjacent areas are world famous for their highly-prized gemstones, such as tourmaline, topaz, and garnet. While it is not typically thought of as a source of critical elements, it was at one time the primary source of lithium in the United States and has also been prospected as a source of beryllium and cesium. Here we give a survey of the history of critical element occurrence and production in the region and additionally present a geochemical trace element survey of the district.

Many of the district's pegmatites fall into the Lithium-Cesium-Tantalum (LCT) classification first described by Petr Černý (Černý 1991a, 1991b). This classification implies enrichment in lithium, cesium, and tantalum relative to more primitive pegmatites, and indeed all three elements are represented in the district's mineralogy to varying degrees. The present study examines each of these critical elements in turn, combining historical context with new trace element data from quartz samples collected across the district.

2. Lithium Occurrence and Production

Many of the district's pegmatites fall into the Lithium-Cesium-Tantalum (LCT) classification, so it is not surprising that lithium minerals are widespread throughout the region. Of the minerals with high lithium content, lepidolite is the most common, with spodumene and amblygonite typically only making up very small proportions of the pegmatite mass, if they occur at all. So, despite the LCT nature of the pegmatites, only a couple are recognized as having large enough quantities of lepidolite that they might be considered as a source of lithium ore.

The most famous occurrence of lepidolite in the area is the Stewart Lithia Mine, near the town of Pala. In this very large pegmatite, lepidolite is present as a rock-forming mass (Patterson 2010). Figure 1 illustrates a representative sample of lepidolite from the Stewart Mine, with a rock hammer for scale. Figure 2 shows lepidolite from the Royal Mine, south of Julian, another important source of ornamental lepidolite.



Figure 1. Lepidolite from the Stewart Lithia Mine, Pala, San Diego County. Rock hammer shown for scale. This mine was the principal source of lithium ore in the United States during the late 19th and early 20th centuries.



Figure 2. Lepidolite specimen from the Royal Mine (also known as the Thursday Mine), south of Julian, San Diego County. Quarter shown for scale.

Production of lithium in San Diego County began in the late 1880s and dwindled by 1930, with total recorded production of 21,300 tonnes of ore (Norton and Schlegel 1955). The primary ore was lepidolite, with minor production from amblygonite (Jahns and Wright 1951). Nearly all output was from the Stewart Mine in Pala. The primary use for San Diego lithium was in the production of lithium salts for "mineral waters and effervescing tablets" widely used as a tonic (Norton and Schlegel 1955), and possibly for psychiatric medical use. Interestingly, production at the Stewart Mine (and other operative mines in South Dakota) seems to have increased during WWI and just beyond, with peaks in 1918 and 1920, for reasons poorly established.

With the rise of cheap overseas sources for lithium, there has been no production of lithium ore from the region for at least the last half century, although some production of lepidolite has continued for ornamental purposes, primarily from the Stewart Mine but also from the Royal/Thursday Mine south of Julian, where perhaps tens of tonnes of lepidolite has been produced. If demand for domestic sources of lithium rises, it is possible that interest in production from the region might rise again. It is interesting to note that the total lithium mined from the area would be enough to supply the entire domestic electric vehicle (EV) market for approximately one year.

3. Beryllium Occurrence in the District

Beryl is ubiquitous in the complex pegmatites of San Diego County and is the primary beryllium mineral found in the district. Rarely, other beryllium minerals have been reported from the area — notably hydroxyherderite — but only in very minor concentrations. In the southeast portion of the region, near Tule Mountain, beryl has been found in large crystals (reportedly approximately 1 m in length), and the federal government undertook a beryllometer survey during World War II, but no commercially exploitable deposits were found.

Figure 3 illustrates a typical beryl crystal from the Charlie Dog Mine, approximately 12 cm in length, in matrix with a quarter shown to the left for scale. Beryl from San Diego County is typically pale blue to colorless (aquamarine), though gem-quality material has been reported from several localities.



Figure 3. Beryl crystal (approximately 12 cm) from the Charlie Dog Mine, in matrix. Quarter shown to the left for scale.

4. Cesium Occurrence in the District

Pollucite has been found in several pegmatites in San Diego County. The most important find is the one in the Himalaya–San Diego Mine dike that led to the company General Electric obtaining a lease on the property in 1929 (Weber 1963, Rynerson 1967). Little to no pollucite was found at that time, and although no doubt present in the mines, it was largely ignored until a large pod was found in the Himalaya portion of the dike in 1998 (Jacobson 2020). A few kilograms of pollucite were removed by Dr. Jeffrey Patterson and the first author of this paper, but the vast majority of it — estimated at approximately 900 tonnes — was left in place. The pollucite was relatively pure except for inclusions of elbaite and small veinlets of lepidolite.



Figure 4. Pollucite from the Himalaya Mine, Mesa Grande, San Diego County, with associated elbaite (pink tourmaline crystals). Quarter shown for scale.

5. Trace Element Analysis: Sampling and Methods

As a means to gain insight into the occurrence of these elements and their possible economic potential, quartz samples were analyzed from 13 local mines and prospects (Figure 5). In no way were these sites chosen to be exhaustive or fully representative of the district. This study has been privately funded by the senior author and is considered to be at an early stage — a guide to a path forward rather than a conclusive or exhaustive investigation. Analysis was performed by four-acid digestion followed by inductively coupled plasma mass spectrometry (ICP-MS) at Activation Laboratories, Ontario, Canada (Report No. A24-12138, dated 14 November 2024).

Samples were selected to examine trace elements contained in core and pocket quartz with a minimum of inclusions. This approach follows established methods for trace element characterization of pegmatitic quartz; a detailed discussion of such analysis can be found in Müller et al. (2021).

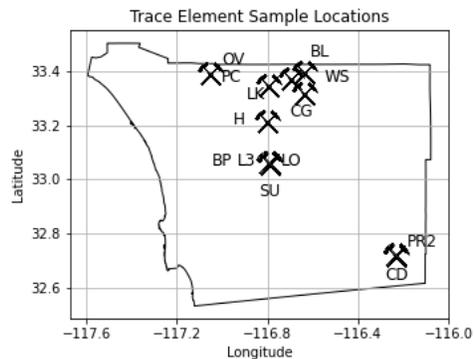


Figure 5. Map showing trace element sample locations across the San Diego County pegmatite district. Abbreviations correspond to mine/prospect names listed in Table 1.

6. Trace Element Analysis Results

The trace element analyses showed, perhaps unsurprisingly, that there were wide variations in the concentrations of the analyzed elements in the quartz samples (Table 1). The least variable element was beryllium, which ranged from below detectable limits to 0.6 ppm at the Little Three Mine in Ramona. This limited range is probably more indicative of the low tendency for beryllium to substitute into the quartz lattice than of any geochemical trend.

Lithium and cesium concentrations varied widely. In the case of cesium, the range spans more than a factor of 300 between the most- and least-enriched samples, while lithium varied by more than a factor of 30. The Oceanview Mine yielded the highest values for both lithium (153 ppm) and cesium (30.4 ppm), while the Little Three Mine returned the highest beryllium value (0.6 ppm) and a notably elevated cesium concentration (24 ppm). Unfortunately, due to the limited number of samples analyzed, it is not possible to determine with certainty whether these results reflect sample-to-sample disparities within individual mines or whether they are robust indicators of mine-to-mine variation.

Table 1. Li, Be, and Cs concentrations (ppm) in quartz samples from San Diego County pegmatites, analyzed by 4-acid digestion / ICP-MS (Activation Laboratories, 2024).

Mine / Prospect	Li (ppm)	Be (ppm)	Cs (ppm)
Black Panther Ext. (BP)	5	< 0.1	2.87
Blue Lady (BL)	19.5	0.2	4.48
Himalaya (H)	17.4	< 0.1	1.4
Lindsey K (LK)	4.7	< 0.1	0.15
Little Three (L3)	21.5	0.6	24
Lookout (LO)	4.8	< 0.1	0.08
Oceanview (OV)	153	0.4	30.4
Pack Rat 2 (PR2)	14.4	0.1	0.58
Pala Chief (PC)	8	< 0.1	< 0.05
Surprise (SU)	8.9	0.1	1.21
Wendy Sue (WS)	11.3	0.1	3.17
Charlie Dog (CD)	4.4	0.3	0.09
Cryo-Genie (CG)	17	0.1	0.37

7. Conclusions and Future Directions

Current markets for critical elements do not justify exploitation of lithium, beryllium, and cesium deposits in San Diego County. However, it is possible that increased future demand may provide motivation for reconsideration of these resources. There is also the possibility that further trace element sampling of the region may lead to discovery of deposits of greater economic potential. The results for cesium in particular, and the dearth of historic exploration for it, suggest there may be previously unrecognized commercial potential in the region.

Future work should expand the number of sample sites and sample types beyond quartz, incorporate additional elements, and explore whether elevated cesium values observed at certain mines (notably Oceanview and Little Three) are spatially systematic. Additionally, assessment of the relationship between trace element concentrations in quartz and the occurrence of cesium-bearing minerals such as pollucite would help contextualize the significance of these geochemical anomalies.

Acknowledgments

The trace element analyses were performed at Activation Laboratories, Ontario, Canada (Report No. A24-12138). This study was privately funded by the senior author. The authors thank the mine owners and operators who provided access for sample collection.

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