

## **Seaborgite, $\text{LiNa}_6\text{K}_2(\text{UO}_2)(\text{SO}_4)_5(\text{SO}_3\text{OH})(\text{H}_2\text{O})$ , the first uranyl mineral containing lithium**

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### **ABSTRACT**

Seaborgite (IMA2019-087),  $\text{LiNa}_6\text{K}_2(\text{UO}_2)(\text{SO}_4)_5(\text{SO}_3\text{OH})(\text{H}_2\text{O})$ , is a new mineral species from the Blue Lizard mine, Red Canyon, San Juan County, Utah, U.S.A. It is a secondary phase found on gypsum in association with copiapite, ferrinatrite, ivsite, metavoltine, and römerite. Seaborgite occurs in sprays of light-yellow, long flattened prisms or blades, up to about 0.2 mm in length. Crystals are elongated on [100], flattened on {010}, and exhibit the forms {100}, {010}, {001}, and {101}. The mineral is transparent with vitreous luster and very pale-yellow streak. It exhibits bright lime-green fluorescence under a 405 nm laser. The Mohs hardness is  $\sim 2\frac{1}{2}$ . The mineral has brittle tenacity, curved or conchoidal fracture, and one good cleavage on {100}. The measured density is 2.97(2) g/cm<sup>3</sup>. The mineral is immediately soluble in H<sub>2</sub>O at room temperature. The mineral is optically biaxial (–),  $\alpha = 1.505(2)$ ,  $\beta = 1.522(2)$ ,  $\gamma = 1.536(2)$  (white light);  $2V_{\text{meas}} = 85(1)^\circ$ ; moderate  $r < v$  dispersion; orientation  $X \wedge \mathbf{a} \approx 10^\circ$ ; pleochroic  $X$  colorless,  $Y$  and  $Z$  light green-yellow;  $X < Y \approx Z$ . EPMA and LA-ICP-MS analyses of seaborgite undermeasured its Li, K, and Na. The empirical formula using Li, Na, and K based on the structure refinement is  $\text{Li}_{1.00}\text{Na}_{5.81}\text{K}_{2.19}(\text{UO}_2)(\text{SO}_4)_5(\text{SO}_3\text{OH})(\text{H}_2\text{O})$ . Seaborgite is triclinic,  $P\bar{1}$ ,  $a = 5.4511(4)$ ,  $b = 14.4870(12)$ ,  $c = 15.8735(15)$  Å,  $\alpha = 76.295(5)$ ,  $\beta = 81.439(6)$ ,  $\gamma = 85.511(6)^\circ$ ,  $V = 1203.07(18)$  Å<sup>3</sup>, and  $Z = 2$ . The structure ( $R_1 = 0.0377$  for 1935  $I > 2\sigma I$ ) contains  $[(\text{UO}_2)_2(\text{SO}_4)_8]^{4+}$  uranyl-sulfate clusters that are linked into a band by bridging LiO<sub>4</sub> tetrahedra. The bands are linked through peripheral SO<sub>4</sub> tetrahedra forming a thick heteropolyhedral layer. Channels within the layers contain a K site, while an additional K site, six Na sites, and an SO<sub>3</sub>OH group occupy the space between the heteropolyhedral layers.

**Keywords:** Seaborgite, new mineral species, lithium, uranyl sulfate, crystal structure, Blue Lizard mine, Red Canyon, Utah