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Atomic-scale visualization and quantification of lithium in lepidolite by AC-TEM-EELS: Implications for pegmatite genesis and advancing lithium extraction techniques

Mao-Wen Yuan[1,2,3], Xiao-Wei Li[1,2,4,*,†], Joshua J. Schwartz[5,‡], Zhi-Dan Zhao[1,2*], Zhao-Ge Hao[1,2,§], Jia-Wei Liu[1,2], Masroor Alam[6], Guo-Chen Dong[1,2], Wan-Ming Yuan[1,2], and Zi-Hao Wen[1,7,‖]

[1]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China
[2]School of Earth Science and Resources, China University of Geosciences, Beijing 100083, China
[3]Journal Center, China University of Geosciences, Beijing 100083, China
[4]School of Earth and Environmental Sciences, Cardiff University, Cardiff, Wales CF10 3AT, U.K.
[5]Department of Geological Sciences, California State University Northridge, Northridge, California 91330, U.S.A.
[6]Department of Earth Sciences, Karakoram International University, Gilgit 15100, Pakistan
[7]School of Gemology, China University of Geosciences, Beijing 100083, China

Abstract

The small ionic radius of lithium ions (Li^+ = 0.6 Å) poses a significant challenge in visualizing and quantifying their presence within the lepidolite lattice. Nevertheless, the use of spherical aberration-corrected transmission electron microscopy (AC-TEM) in conjunction with electron energy loss spectroscopy (EELS) offers an innovative approach to surmount this challenge. In this investigation, we conducted a comprehensive analysis of lepidolite samples obtained from lithium-rich pegmatites in the Shaliuquan region of the Quanji Massif, situated at the northwestern periphery of the Qinghai-Tibetan Plateau in northwest China. Utilizing AC-TEM in tandem with EELS, we captured sub-angstrom images revealing the presence and spatial distribution of lithium atoms within the lepidolite lattice. Additionally, we quantified their concentrations and determined the formula for lithium-rich mica. This study solves a long-standing problem regarding the accurate determination of lithium concentration and showcases the viability of AC-TEM-EELS for both visualizing and quantifying lithium within the lepidolite lattice. Our finding facilitates the differentiation of cation ordering, polytypes, and lepidolite's chemical compositions, which is helpful for advancing lithium extraction techniques and constraining the forming process of pegmatites.

Keywords: Spherical aberration-corrected transmission electron microscopy, electron energy loss spectrometry, lithium, lepidolite, pegmatite, Special Collection: Pegmatites