American Mineralogist, Volume 110, pages 866–885, 2025

Cathodoluminescence textures and trace elements in quartz: Constraints on Ag mineralization in adularia-sericite epithermal systems

Shen Gao[1,2,*], Xinyu Zou[3], Albert H. Hofstra[4], Liangliang Huang[3], Haijun Yang[5], Kezhang Qin[3,6,§], Erin E. Marsh[4], Kaixuan Hui[3], Jing Xu[7,†], Le Wang[3], Zhenzhen Li[8], Junxing Zhao[3,‡], Ri Han[3], and Guangming Li[3]

[1]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China
[2]School of Earth Sciences and Resources, China University of Geosciences (Beijing), Beijing 100083, China
[3]State Key Laboratory of Lithospheric and Environmental Coevolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[4]U.S. Geological Survey, P.O. Box 25046, Denver, Colorado 80225, U.S.A.
[5]Department of Chemistry, Tsinghua University, Beijing 100084, China
[6]College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing 100049, China
[7]Zijin School of Geology and Mining, Fuzhou University, Fuzhou 350108, China
[8]China Institute of Disaster Prevention, Sanhe 065201, China

Abstract

Quartz chemistry is important for revealing fluid sources and evolution in hydrothermal deposits, but such information is lacking for many epithermal systems and deposit types. To investigate quartz chemistry in this system further, we collected representative samples of quartz from adularia-sericite epithermal Ag deposits in China and determined their chemical compositions. In adularia-sericite epithermal Ag-bearing systems, magmatic quartz from porphyry intrusions and host subvolcanic rocks displays SEM-CL spectral peaks at 360 and 415 nm and exhibits homogenous CL or weak zonal textures (alternating growth zones within individual quartz crystals). Trace elements in magmatic quartz have the lowest Sb concentrations (median = 0.1 ppm; n = 80). Hydrothermal quartz can be classified into type I and type II by CL false color and CL spectral peaks. Hydrothermal type I quartz has spectral peaks at 360 and 415 nm; it exhibits zonal or sector textures and is associated with base metal sulfides and minor Ag mineralization. Such hydrothermal type I quartz has low Sb concentrations (median = 4.5 ppm; n = 839), contains liquid-rich fluid inclusions, and is formed by cooling. The cooling trend is indicated by a positive correlation between the concentrations of Sb and Al, as well as between Li and Al. Hydrothermal type I quartz has an Fe center by electron spin resonance, whereas other centers are missing or weak at room temperature. In general, hydrothermal type II quartz mantles type I quartz. Hydrothermal type II quartz has an ultrahigh-intensity peak (by several orders of magnitude) at 580 nm, zonal textures, and is associated with abundant Ag mineralization. Hydrothermal type II quartz has the highest Sb concentrations (median = 71 ppm; n = 185), which remain constant as Al decreases on an Sb vs. Al plot. This quartz has colloform, bladed, or zonal textures and contains coexisting liquid- and vapor-rich fluid inclusions indicative of boiling. Additionally, this quartz has a significantly higher E'1 center intensity, suggesting a high concentration of oxygen vacancies associated with rapid crystallization. The mineral paragenesis, analytical results, and geochemical models show that, in these Ag-bearing epithermal systems, hydrothermal type I quartz associated with base metal sulfides precipitated during cooling, whereas subsequent growth-zoned hydrothermal type II quartz with high Sb concentrations and Ag-minerals precipitated during boiling. These results suggest that the CL texture and spectra, trace elements, and electron spin resonance data of quartz could identify veins with potential for Ag mineralization in epithermal systems.

Keywords: Quartz, CL, trace elements, ESR, adularia-sericite, epithermal, Ag mineralization