American Mineralogist, Volume 106, pages 497–505, 2021

Gamma-enhancement of reflected light images: A rapid, effective tool for assessment of compositional heterogeneity in pyrite

QiaoQiao Zhu[1,2], Nigel J. Cook[2], GuiQing Xie[3,*,‡], Cristiana L. Ciobanu[4], Wei Jian[1], Benjamin P. Wade[5], and Jing Xu[4,6,†]

[1]MNR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, CAGS, Beijing 100037, China
[2]School of Civil, Environmental and Mining Engineering, The University of Adelaide, Adelaide, South Australia 5005, Australia
[3]Institute of Earth Science, China University of Geosciences, Beijing 100083, China
[4]School of Chemical Engineering and Advanced Materials, The University of Adelaide, Adelaide, South Australia 5005, Australia
[5]Adelaide Microscopy, The University of Adelaide, Adelaide, South Australia 5005, Australia
[6]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Abstract

Trace/minor element variation in pyrite is a feature that has proved invaluable for reconstructing a wide range of geological processes. Routine reflectance observations commonly fail to constrain this variation due to the typically subtle and barely perceptible change in reflectance brought about by deviation from ideal stoichiometry. Such differences may be difficult or impossible to observe in conventional polished sections using standard optical microscopes, at least without oil immersion. Chemical etching and staining, although widely used, are destructive, hazardous, or both, and the etching process is not completely reproducible. Here we use the γ correction method to enhance optical digital signal differences obtained in reflected light to constrain compositional heterogeneity in pyrite from a representative hydrothermal ore deposit in eastern China. The γ-enhanced images show significant reflectance variation caused by compositional heterogeneity, confirmed by quantitative electron microprobe analysis and qualitative imaging. Higher reflectance domains in γ-enhanced images correspond to increases in the effective number of free electrons, whereas darker domains are attributed to the decrease of these free electrons by trace/minor element substitution in pyrite (e.g., As). Gamma correction provides a rapid, effective, non-destructive method to constrain compositional heterogeneity of pyrite through enhancement of reflectance variation. Used alone, this method is unable to determine the chemical composition due to simultaneous substitutions, causing a disparate increase or decrease of reflectance, in most ore minerals. Nevertheless, γ correction may be sufficient to predict the substitution of trace/minor elements under the optical microscope prior to scanning electron microscope imaging and quantitative investigation of mineral composition and may help constrain links between textures and compositions of pyrite in evolving ore systems, which could also be applied to other ore minerals with negligible bireflectance.

Keywords: Compositional heterogeneity, reflectance, pyrite, non-destructive analysis, Gamma correction; Understanding Paleo-Ocean Proxies: Insights from In Situ Analyses