American Mineralogist, Volume 103, pages 1487–1496, 2018

Disturbance of the Sm-Nd isotopic system by metasomatic alteration: A case study of fluorapatite from the Sin Quyen Cu-LREE-Au deposit, Vietnam

Xiao-Chun Li[1,*], Mei-Fu Zhou[1,*], Yue-Heng Yang[2], Xin-Fu Zhao[3], and Jian-Feng Gao[4]

[1]Department of Earth Sciences, The University of Hong Kong, Hong Kong SAR, China
[2]State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
[3]State Key Laboratory of Geological Processes and Mineral Resources, and Faculty of Earth Resources, China University of Geosciences, Wuhan 430074, China
[4]State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002, China

Abstract

The Neoproterozoic (840 Ma) Sin Quyen deposit in northwestern Vietnam contains replacement Cu-LREE-Au orebodies in Proterozoic metasedimentary rocks. In this deposit, LREE-bearing minerals include allanite-(Ce), monazite-(Ce), chevkinite-(Ce), and fluorapatite. Fluorapatite from orebodies has undergone variable degrees of metasomatic alteration. Samarium-neodymium isotopic analyses were conducted on altered fluorapatite, and also on allanite-(Ce) and monazite-(Ce), to investigate whether such metasomatism can affect the Sm-Nd isotope system.

Allanite-(Ce) and monazite-(Ce) have $^{147}Sm/^{144}Nd$ ratios ranging from 0.0359 to 0.0549, and $^{143}Nd/^{144}Nd$ ratios from 0.51147 to 0.51172. Their initial $^{143}Nd/^{144}Nd$ values at the time of mineralization range from 0.51126 to 0.51148, but mostly cluster between 0.51135 and 0.51145. Thus, the primary ore-forming fluids were relatively homogeneous in their Sm-Nd isotopic compositions. In the $^{147}Sm/^{144}Nd$ vs. $^{143}Nd/^{144}Nd$ diagram, the compositions of allanite-(Ce) and monazite-(Ce) generally plot along a Sm-Nd isochron of 840 Ma, implying that the Sm-Nd isotopic systems of these minerals were either closed or only slightly modified. In contrast, altered fluorapatite crystals have $^{147}Sm/^{144}Nd$ ratios varying from 0.0667 to 0.1348, and $^{143}Nd/^{144}Nd$ ratios from 0.51160 to 0.51199. The calculated initial $^{143}Nd/^{144}Nd$ ratios range widely from 0.51114 to 0.51141, with most values lower than those of the allanite-(Ce) and monazite-(Ce). In the $^{147}Sm/^{144}Nd$ vs. $^{143}Nd/^{144}Nd$ diagram, their compositions mostly plot below the 840-Ma Sm-Nd isochron. Petrographic observations and trace elemental analyses show that metasomatic modification of fluorapatite grains led to increases of their Sm/Nd ratios. The unaltered domains in the grains have Sm/Nd ratios varying from 0.114 to 0.200, with an average value of 0.161; whereas the altered domains have Sm/Nd ratios varying from 0.111 to 0.254, with an average value of 0.183. The increased Sm/Nd ratios can cause the calculated initial $^{143}Nd/^{144}Nd$ ratios to be lower than actual initial isotopic ratios, and can also result in compositional deviations from the reference Sm-Nd isochron.

This study demonstrates that the traditionally assumed inert Sm-Nd isotopic system can be metasomatically disturbed due to changes in the Sm/Nd ratio. Therefore, care must be taken when interpreting the Sm-Nd isotopic data from apatite/apatite-rich rocks that have undergone metasomatic alteration.

Keywords: Apatite, metasomatic alteration, Sm-Nd isotopes