

Resetting of the U-Pb and Th-Pb systems in altered bastnäsite: Insight from the behavior of Pb at nanoscale

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ABSTRACT

Bastnäsite contains considerable amounts of U and Th and has been widely used for U-Th-Pb dating. Hydrothermal alteration of bastnäsite is common in nature but its effects on U-Th-Pb dating are not currently well constrained. Hence the significance of U-Th-Pb ages obtained from altered bastnäsite cannot be evaluated. Here, we present a detailed geochronologic as well as micro- and nano-scale mineralogical study of altered bastnäsite in a Mo-REE deposit, Central China. The original bastnäsite grains were confirmed to have crystallized at 208 Ma but were variably overprinted by a hydrothermal event at 150 Ma. They commonly exhibit typical replacement textures that appear to have formed from a coupled dissolution-reprecipitation process, i.e., a primary unaltered domain surrounded by a porous altered domain. Micro- and nano-scale mineralogical observations strongly suggest that during the coupled dissolution-reprecipitation process, non-radiogenic (common) Pb was incorporated into the altered domains in the form of nanoscale galena inclusions. Such incorporation (even minor) has significantly affected the $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{206}\text{Pb}$ ratios due to the low contents of U and its daughter isotopes in bastnäsite, resulting in highly variable, discordant U-Pb dates for the altered domains. In contrast, incorporation of the non-radiogenic Pb has very limited effects (<5%) on the Th-Pb system due to the remarkably high contents of Th and radiogenic ^{208}Pb in bastnäsite. Instead, the scattered $^{208}\text{Pb}/^{232}\text{Th}$ ages (208 to 150 Ma) of the altered domains were essentially affected by incomplete replacement, and thus can be used to approximate the lower age limit of the primary hydrothermal activity or the upper age limit of the secondary hydrothermal activity. The results from this study highlight that because of the different orders of magnitude between the U and Th contents in bastnäsite, the mobilization of radiogenic and non-radiogenic Pb during alteration may have significantly different impacts on the U-Pb and Th-Pb systems. Therefore, the two systems should be treated separately during the dating of bastnäsite resulting from secondary hydrothermal events.

Keywords: Bastnäsite, dissolution-reprecipitation, reset, U-Th-Pb ages, Huangshuian Mo-REE deposit