Chemical and isotopic changes during metasomatic alteration of apatite

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Apatite is a common mineral in iron-oxide copper gold (IOCG) and iron-oxide apatite (IOA) deposits. It normally contains various trace elements [e.g., halogens, S, Sr, and rare earth elements (REE)], which can be used to document the mineralizing conditions. In addition, Sr, Nd and O isotopes of apatite can be effectively employed to trace the source and evolution of the ore-forming fluids. However, it has been documented that apatite can be partially or completely metasomatically altered by hydrothermal fluids, which raises questions about the interpretation of elemental and isotopic compositions (Harlov et al. 2002; 2005). Major and trace element compositions, and Sr, Nd and O isotopic ratios, were determined on altered apatite from several IOCG and IOA deposits in China, to investigate the metasomatic effect on chemical and isotopic changes (Li and Zhou 2015; Zeng et al. 2016).

Our studies show that the hydrothermal alteration of apatite can occur either shortly after the formation of apatite, or hundreds of millions of years after the formation of apatite. We also found that apatite may have undergone multiple stages of alteration. Hydrothermal alteration of apatite can result in the leaching of REE and other trace elements, such as U, Th, Sr and Ba (Fig. 1). There are also apatite grains which have experienced leaching and immediate re-precipitation of REE, so they may contain abundant REE-rich mineral inclusions in or adjacent to altered regions (Fig. 2). Hydrothermal alteration of apatite can also lead to significant shifts of the $^{87}Sr/^{86}Sr$ and $^{18}O/^{16}O$ ratios. The $^{143}Nd/^{144}Nd$ ratios are either weakly or strongly changed during metasomatism, and the Sm/Nd ratio can be significantly changed. These will hinder obtaining the primary initial Nd isotopic composition.

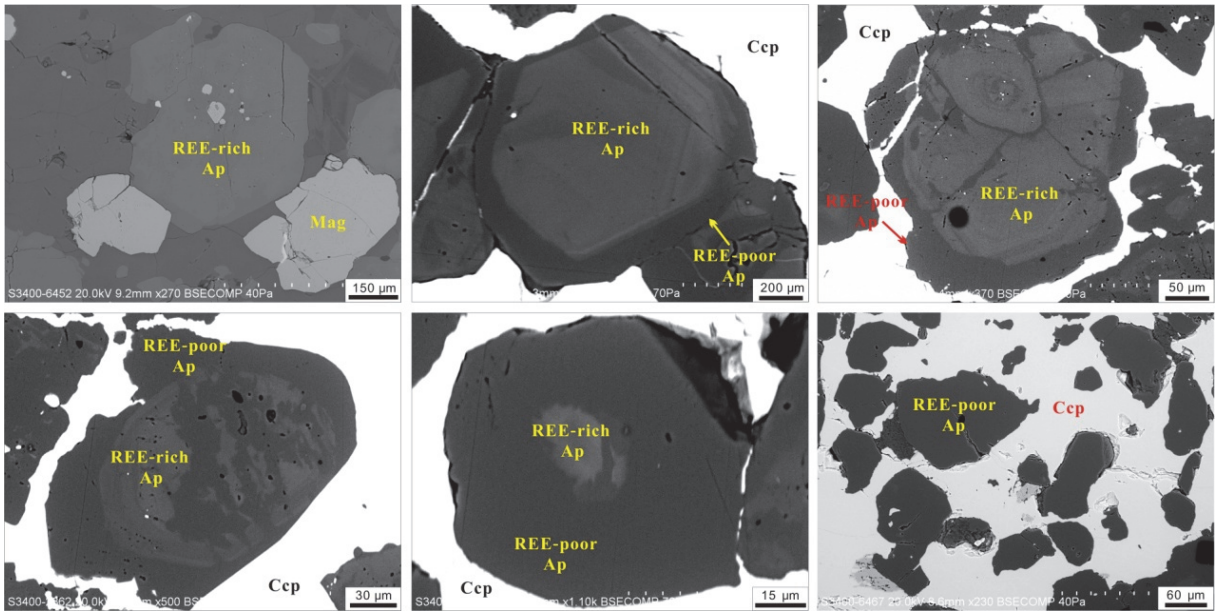

Fig. 1. *Variable degrees of REE leaching during metasomatic alteration of apatite*

Our study highlights that elemental and isotopic compositions of fluorapatite can be significantly modified by hydrothermal fluids during ore-forming events. Thus, instead of traditional bulk-rock analysis, in situ microanalysis is important to provide accurate constraints on the magmatic and/or hydrothermal evolution of complex ore-forming systems.

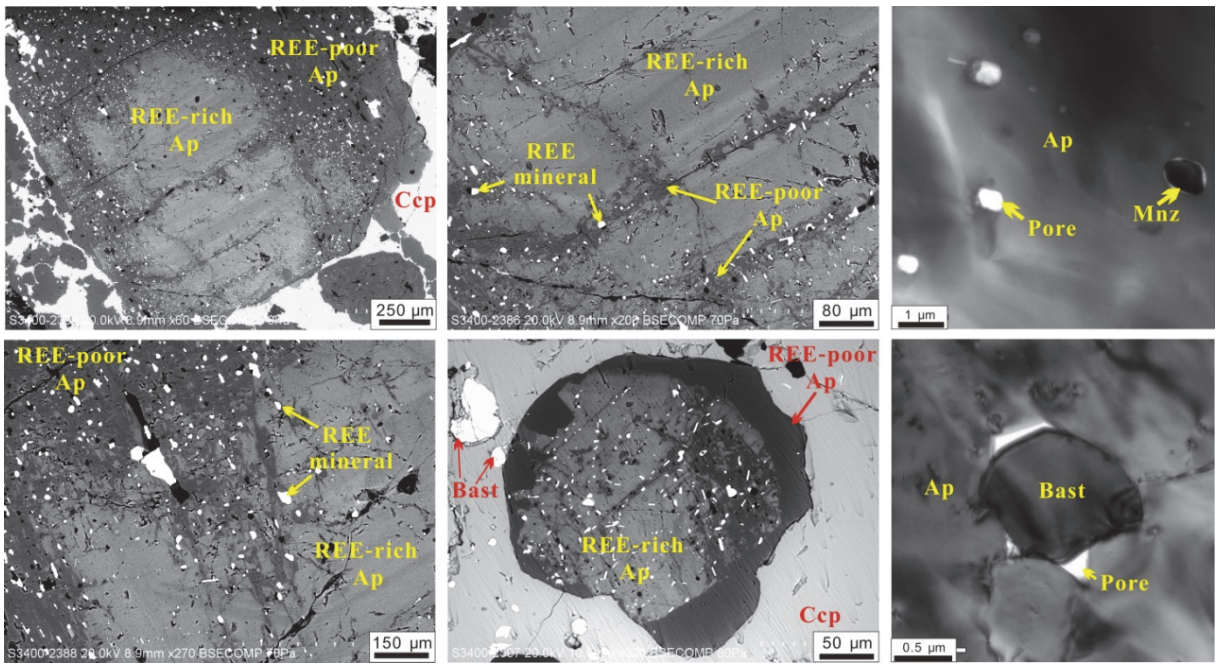

Fig. 2. *Leaching and immediate precipitation of REE during metasomatic alteration of apatite*

Acknowledgments: *Mr. Yu Fan Chan from HKU, Dr. Jingyuan Chen from CAU, and Dr. Wenlan Zhang from NJU are thanked for assistance with the laboratory work. Prof. Daniel E. Harlov from GFZ is greatly appreciated for fruitful discussion.*

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