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Fluid metasomatism of fluorapatite from iron-oxide apatite deposits using in situ elemental and isotopic analysis: A case study from Eastern China

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Metasomatic alteration of fluorapatite has been reported in several iron-oxide apatite (IOA) deposits, but its effect on elemental and isotopic variations has not been well understood. In this study, we present integrated elemental, U-Pb, Sr, and O isotopic microanalytical data on fresh and altered domains offluorapatite from the Taocun IOA deposit inEastern China, to evaluate the timing and nature of the metasomatism and its effects on the ore-forming event.

The Taocun deposit is a representative IOA deposit in the Middle-Lower Yangtze River Valley Metallogenic Belt. The orebodies are spatially associated with a subvolcanic, intermediate intrusion, which displays zonal alteration patterns with albite in the center and increasing actinolite, chlorite, epidote, and carbonate toward the margin. There are two types of ores, including early disseminated magnetiteand late magnetite veins. Both types of ores contain abundant fluorapatite.

Microscopic and BSE images have shown that the fluorapatite grains from the both types of ores have been variably metasomatized through a coupled dissolution-reprecipitation mechanism. The altered domains preserve the shape and orientation of the primary crystals; but have pervasive micro-porosities and fluid inclusions. Many trace elements, including Na, Cl, S, Si, Mg, Sr, U, Th, and (REEs+Y), were variably leached from the fluorapatite grains during this process and the Sr and O isotopic signatures of the grains were also modified. The altered fluorapatite grains/domains have in situ $^{87}Sr/^{86}Sr$ ratios (0.70829–0.70971) slightly higher than those of the fresh fluorapatite (0.70777–0.70868), and $\delta^{18}O$ values (–3.0 to +3.4‰) variably lower than the primary domains (+5.3 to +7.5‰). The Sr and O isotopes of the primary fluorapatite are consistent with or slightly higher than those of the ore-hosting intrusion, implying that the early-stage, ore-forming fluids were magmatic in origin but underwent weak interaction with the country rocks.

U-Pb dating of the fresh and altered domains of the fluorapatite yielded indistinguishable ages of ~131 Ma, which are the same as the age of the ore-hosting intrusion. In combination with fluid inclusion data, we propose that the metasomatism of fluorapatite was induced by hydrothermal fluids at a late stage of the ore-forming event. The shifts to higher $^{87}Sr/^{86}Sr$ ratios and lower $\delta^{18}O$ values for the altered fluorapatite indicate that the alteration was induced by fluids with more radioactive Sr and lighter O isotope signatures. The metasomatic fluids were likely dominated by meteoric waters that were mixed with the earlier magmatic fluids and interacted with sedimentary rocks. 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 magmatic and/or hydrothermal evolution of complex ore-forming systems.