

Mobilization and Mineralization of Rare Earth Elements in the Lala Fe-Cu-(Mo, REE) Deposit, SW China

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The Lala Fe-Cu-(Mo, LREE) deposit in Sichuan province, SW China, has a paragenetic sequence of Stage I of pre-ore Na-alteration, Stage II of magnetite and apatite, and Stage III of Cu-(Mo) sulfides and rare earth element (REE) minerals, similar to IOCG-type deposits. REE minerals are mainly monazite, parisite and bastnäsité, associated with biotite, muscovite and calcite and related K-Ca-carbonate alteration of Stage III. In places where magnetite and apatite of Stage II are overprinted by minerals of Stage III, the apatite grains are commonly embayed or eroded, and contain abundant monazite inclusions with minor bastnäsité, calcite and sulfide minerals. These monazite-bearing apatite grains are similar to the metasomatized apatite reported in experiments, and thus are suggested to have formed from the Stage II apatite via a dissolution-precipitation process related to the Stage III fluids. Such a fluid metasomatism has mobilized and leached LREEs from the primary Stage II apatite. Similarly, LREEs of country rocks altered by the Stage III fluids are also mobilized and leached out during alteration, which was suggested to be responsible for subsequent REE mineralization in the Lala deposit.

Mineral assemblages of Stages II and III, previous fluid inclusion data, and compositions of amphibole and biotite demonstrate that Stage III fluids have higher K, CO₂ (or HCO₃⁻ and CO₃²⁻) and HF/HCl fugacity but lower salinity and Na activity than Stage II fluids. We suggest that elevated K and CO₂ in Stage III fluids or associated K-carbonate alteration are possibly important for LREE mobilization. The mobilized LREEs from country rocks were inferred to be transported as chlorite-complexing before depositing as REE minerals at certain levels. Deposition of REE minerals was likely triggered by mixing with relatively low-temperature, F-rich, and oxidized basinal brines and/or local interaction with carbonate hosts. We propose that the common association of REEs with Cu mineralization in many IOCG deposits are possibly ascribed to the specific nature of K-CO₂-rich Cu mineralizing fluids.