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The determination of sulfate-carbonate-chloride concentrations in fluid-melt inclusions from Pea Ridge IOA-REE deposit, SE Missouri

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One of our society's most critical challenges is finding the essential resources for the transition to green energy. Among these vital commodities are rare earth elements (REEs), whose distribution in the Earth's crust remains poorly understood. Recent studies have shown evidence of the ubiquitous presence of salt melt inclusions, comprising chlorides, carbonates, and sulfates, within Iron-Oxide Apatite (IOA)-REE deposits has spurred scientific interest in reassessing the processes behind the genesis of these mineralizations and how these carbonate and sulfate-rich melts aid in the mobilization of REEs in the crust [1, 2]. Our research focuses on understanding the characteristics of fluids and melts within the Pea Ridge IOA-REE deposit in southeastern Missouri. Pea Ridge is hosted by Mesoproterozoic igneous rocks in the St. Francois Mountains terrane (1.44-1.48 Ga). The deposit is characterized by a high enrichment in REEs (12% wt. oxide in reserve). The Pea Ridge deposit exhibits four distinct mineralization zones: amphibole-quartz, massive magnetite-specular hematite, silicified, and REE-enriched breccia pipes. Microthermometry analysis indicates a broad temperature range for secondary and subsequent processes, spanning from 100 to 500 ºC. Additionally, the data from microthermometry reveal diverse salinities and eutectic temperatures across the mineralization zones, suggesting a varied composition of fluids. Our objective is to confirm the presence of sulfate-carbonate-chloride salts by analyzing evaporation mounds from fluid-melt inclusions. Chemical mapping of these decrepitated fluid-melt inclusions, conducted using SEM-EDS instruments, is then compared with an array of standard solution anions ranging from 100 to 10,000 ppm. A quantitative approach involving the interpolation of standard solution concentrations is employed to quantify the ratio of anions within the fluid-melt inclusions. Further investigations, including Raman analysis and Laser Ablation ICP Mass Spectrometry, are planned to validate the presence of cations and overall salt-melt composition contributing to the speciation and mobility of REEs within the IOA-REE deposit.

[1] Bain et al. (2020), Nat. Geosci. 13, 751–757
[2] Xu et al. (2024), Geology https://doi.org/10.1130/G51887.1