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Xenotime Solubility in hydrous peralkaline liquids

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Xenotime (YPO_4) is a key host for heavy rare earth elements (HREEs), which are increasingly needed for the green economy. However, many key aspects of its formation remain unclear. For instance, while the largest REE deposits in the world are attributed to silica undersaturated or carbonatitic magmas, xenotime in these deposits occurs along veins in metasomatized country rocks. Previous work shows that hydrous carbonated peralkaline liquids coexist with nepheline and feldspar at 330°C and 1 kb [1]. Here, we seek to understand the petrogenesis of HREE deposits by measuring xenotime solubility in these hydrous peralkaline-carbonatitic liquids over a range in temperatures.

This study presents the results of new solubility experiments examining the ability of peralkaline liquids in the Na_2O-Al_2O_3-SiO_2-H_2O-CO_2 system to transport and deposit xenotime. Knowing how the solubility of xenotime varies with temperature and liquid composition allows us to estimate how these deposits may have formed. We performed experiments at 1 kbar in rapid quench cold-seal systems over a range of temperatures and compositions. Experimental temperatures range from 800 to 330°C. Approximately 0.001 g of natural xenotime (Y) was loaded into Au capsules with approximately 0.02 g of powder of Si-Na-Al-CO_3 composition (approximately 58 wt.% SiO_2; 20.5 wt.% Na_2O; 18.9 wt.% Al_2O_3; 2.6 wt.% CO_3). 18-25 wt% water was added and experiments were vapor saturated. Experiments were held at final temperatures for 16 hours.

Preliminary results indicate that natural xenotime reacts with the peralkaline liquid even at the lowest temperatures (<400°C) and over very short durations (<24 hrs). In high temperature experiments, xenotime exhibits coronal reaction rims rich in Na_2O and P_2O_5. At lower temperatures, xenotime contains rims of crystals enriched in Na-P-Si. Further work will quantify Y and Dy contents of liquids using LA-ICPMS and involve run durations that eliminate reaction rims.

These initial results imply that HREE are quite mobile in hydrous peralkaline liquids over a range in temperatures providing a potential mechanism for forming REE deposits.

[1] Lundstrom et al. (2022) Front. Earth Sci, doi.org/10.3389/feart.2022.970264