

Chemical textures on rare earth carbonates: an experimental approach to mimic the formation of bastnasite

Maddin, M^{*1}, Szucs, AM, Rateau, R, Terribli, L and Rodriguez-Blanco, JD

*maddinm@tcd.ie

¹*Department of Geology, School of Natural Sciences, Trinity College Dublin, Dublin 2, Ireland.*

Rare earth elements (REE) are essential in many green modern technologies and play a critical role in a more sustainable future [1]. However, there is a substantial risk to their supply as the availability of REE deposits with minable concentrations are limited [2]. A better understanding of the mechanisms controlling REE concentration in minerals would have applications in more efficient mining practices as well as REE separation techniques and recycling.

In our study, we investigated the reaction of multi-component REE (La, Ce, Pr, Nd, and Dy) aqueous solutions with carbonate grains of dolomite, aragonite and calcite at hydrothermal conditions (21-210 °C). In order to understand the effect of ionic radii of the five REEs and how these ions ‘compete’ with each other while forming solids, two different solutions were prepared: (i) a solution with equal concentrations of each of the five REE; (ii) a solution with concentrations of the five REEs normalized to a Post Archean Australian Shale standard (PAAS), to mimic the rare earth element concentrations in continental crust and natural fluids.

The interaction between the REE bearing fluids with each of the carbonate grains resulted in the replacement of the host carbonate grain with a series of REE minerals following a complex crystallization sequence (lanthanite → kozoite → bastnasite → cerianite). We have found that for most of the experiments at 165 °C, when using the equal concentration solutions, the crystallization of kozoite was promoted and the REE ratio in the newly formed solids was similar to the REE ratio in solution. In contrast, when PAAS solutions were used, REE-bearing crystals were zoned or had a heterogenous distribution of REEs, often coupled with the formation of discrete REE phases (e.g., cerianite). In addition, chemical signatures indicating the presence of metastable REE-bearing phases that transformed to more thermodynamically stable polymorphs were found in multiple samples as well as symplectite textures formed by the reaction of adjacent phases. Overall, our experiments demonstrate that the polymorph selection, crystallization pathway, the kinetics of mineral formation and the chemical texture of the newly formed rock during the mineral-fluid interaction process are dependent on the REE concentrations in solution, their ionic radii, temperature, time, and solubility of the host grains.

References

- [1] Sinding-Larsen, R., Wellmer, F.W., Non-renewable resource issues: Geoscientific and societal challenges, Non-Renewable Resource Issues: Geoscientific and Societal Challenges 2012.
- [2] Jordens, A., Cheng, Y.P., Waters, K.E., A review of the beneficiation of rare earth element bearing minerals. Miner. 2013 Eng. 41, 97-114.