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Promoting early REE separation during ore leaching: an investigation through controlled synthetic crystal dissolution experiments

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In many REE deposits, the carrier minerals display extensive solid solutions that induce variation in surface and crystal properties which can significantly impact flotation and leaching behaviors. In this context, controlled experiments on synthetic crystalline systems, where structural and chemical variables can be isolated, provide opportunities to better understand important interfacial mechanisms that control collector surface interaction and mineral dissolution. Our study focuses on the compositional space of REE-orthophosphates through the synthesis of analogues along well-defined substitutions with the objective of improving flotation selectivity and identifying optimal dissolution paths.

Here we report the progress of experiments designed to investigate factors that promote early separation of the different REEs during initial orthophosphate cracking in alkali hydroxide solutions. Single natural and synthetic crystals of monazite and xenotime are exposed to caustic solutions of various compositions at pressures up to 20 MPa and temperatures ranging from 140 to 300°C. The impact of sequential dissolution cycles where crystals are periodically quenched and immersed in a fresh solution are also examined. The nature of the resulting REE hydroxide leached layer is characterized by micro X-ray diffraction, field-emission electron probe X-ray microanalysis, dynamic secondary ion mass spectrometry, and transmission electron microscopy.

Our current results indicate that, through a fractional dissolution process, there exist pressure-temperature paths where efficient REE selectivity is achieved with the larger trivalent lanthanides reporting to the solid hydroxide leached phase while partitioning of the heavier REEs in solution increase progressively with decreasing trivalent ionic radii. Optimization of this dynamic dissolution approach could minimize the downstream hydrometallurgical challenges typically associated with REE separation. However, this requires an understanding of the nature and relative thermal stability of specific dissolved REE species. Consequently, strategies for in-situ real-time spectroscopic measurements in high-temperature caustic environments are being developed and preliminary results will be discussed.