Phase equilibria and compressibility of bastnaesite-(La)

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Bastnaesite (Ce,La,Y)CO_3(F,OH) is a rare earth element (REE) bearing ore mineral. REEs are more common in the Earth's crust than precious metals like gold or platinum, but are not commonly concentrated in economically viable ore deposits. For over a decade, China has been the world's leading supplier of REEs. Recent export restrictions from China have necessitated the search for new deposits. Determining basic material properties such as phase equilibria and the equation of state for bastnaesite helps in understanding the processes that form REE ore deposits and thereby assist in locating new deposits.

For this study we focus on the lanthanum-fluoride variant of bastnaesite ($LaCO_3F$) since it can be easily synthesized in the laboratory. Previous work by others determined that in both open and closed systems at atmospheric pressure bastnaesite decomposes to lanthanum oxyfluoride and carbon dioxide ($LaOF + CO_2$) above 325°C; at 100 MPa bastnaesite decomposes above 860°C (Hsu, 1992).

Using a Griggs-type modified piston cylinder apparatus, we pressurized samples of synthetic bastnaesite-(La) to conditions ranging from 250 MPa to 1.2 GPa, and then subjected each sample to constant temperatures ranging from 700°C to 1050°C for a minimum of five hours. We then analyzed the samples with X-ray powder diffraction to identify phases present and determined that bastnaesite-(La) is stable at 250 MPa up to approximately 800°C and at 1.0 GPa up to approximately 900°C. Reversal experiments are underway.

In order to develop an equation of state for bastnaesite-(La), we studied single crystals via monochromatic synchrotron X-ray diffraction in the diamond anvil cell at HPCAT (Sector 16), Advanced Photon Source (APS), Argonne National Laboratory. Measurements were made at pressures ranging from ambient to nearly 4 GPa. From these diffraction patterns, we determine the structure of bastnaesite-(La), and the change in unit cell volume as a function of pressure and temperature can be fit to a Birch-Murnaghan equation of state with $V_0 = 439.2$ Å^3 and $K_0 =$ 117.6 GPa.