Pressure and Temperature Stability of Bastnaesite Containing Rare Earth Elements

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Introduction

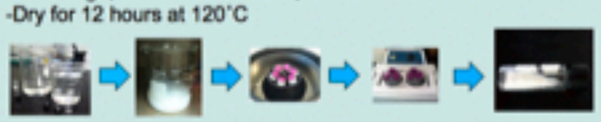
Rare Earth Elements (REE) are relatively abundant throughout the Earth's crust, but they are rarely found in concentrated deposits that can be mined economically. Bastnaesite ($LaCO_3F$) is among the most abundant minerals rich in REE and is mined at Mountain Pass in California.

The Mountain Pass Mine was the leading producer of light REE from the 1960s until the mid-1990s when environmental constraints and international competition took their toll on the Mountain Pass mine. Currently, significant amounts of REE are only produced in a few countries, with China producing over 95% of the world's REE. Over the past two decades there has been a huge surge in demand for REE. Since there is a rising demand for these elements, locating alternative sources may be necessary to ensure that the future supply is not constricted. Our goal is to determine the pressure and temperature dependence of the stability of Bastnaesite in order to find how and where Bastnaesite may have formed so that we may locate other deposits.

Methods

Bastnaesite Synthesis Procedure

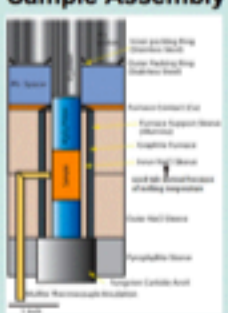
- Mix aqueous $La(NO_3)_3 \cdot 6H_2O$ with aqueous NaF and $NaHCO_3$
- Stir 30 minutes then let sit for 2 hours
- Centrifuge, wash with DI water, and ultrasonic bath 3 times
- Dry for 12 hours at 120˚C



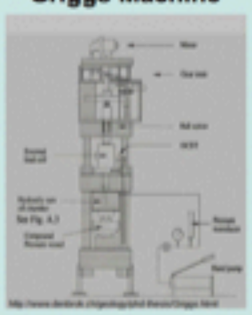
Experimental Procedure

- Construct sample assembly and insert into bomb
- Place bomb into Griggs Machine (a piston cylinder press capable of simulating high temperature and pressure)
- Pressurize Griggs to desired pressure and allow it to equilibrate
- Slowly bring to desired temperature and maintain for ~3 hours
- After trial is completed, quickly return to room temperature and slowly depressurize sample
- Remove sample from assembly and analyze using powder X-ray diffraction (XRD)

Sample Assembly

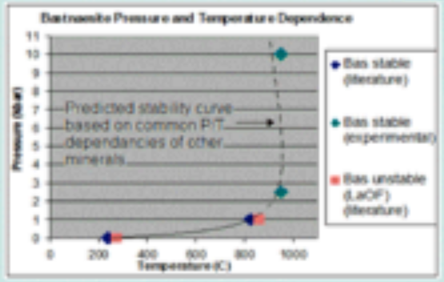


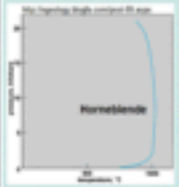
Griggs Machine



-put sample with graphite buffer into weldied shut ¼" platinum capsule (closed system)
-placed into larger ½"platinum capsule with 1 molar solution of NaF and $NaCO_3$, graphite, and talc

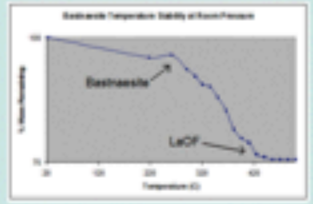
Results



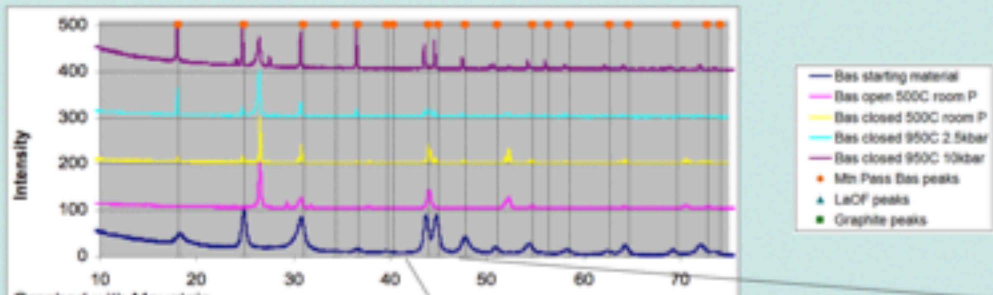


Predicted Decomposition Reaction:

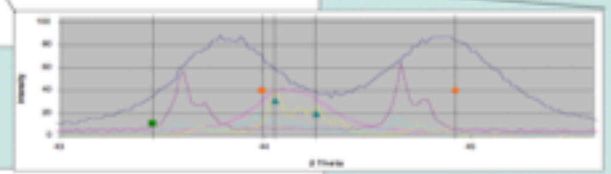
$$LaCO_3F \rightarrow LaOF + CO_2$$

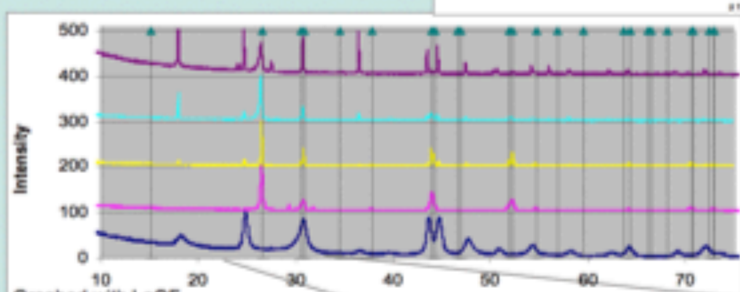


Experimental XRD Data for Results for Runs at Different Pressures and Temperatures

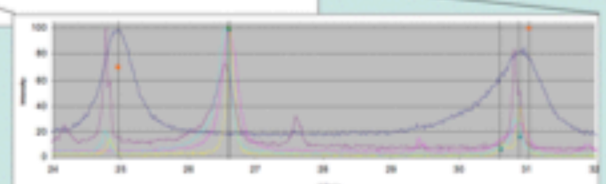


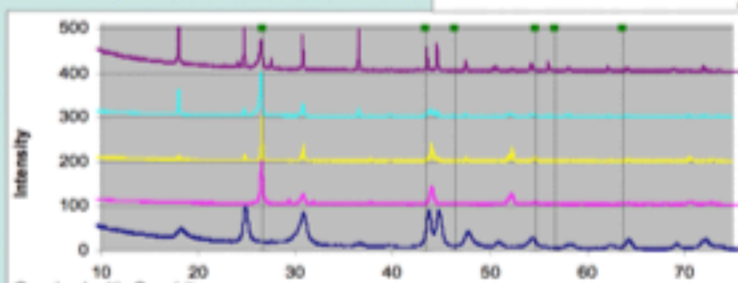
Graphed with Mountain Pass known peaks





Graphed with LaOF known peaks





Graphed with Graphite known peaks

Conclusions

We were able to verify that in an open environment Bastnaesite decomposed into LaOF at ~300°C at atmospheric pressure. To test higher temperatures and pressures we completed two runs at 950°C, one at 10Kbar and the other at 2.5Kbar. The resulting analysis did not show decomposition into LaOF. It appears that instead the Bastnaesite recrystallized. This is seen by the narrowing of the XRD peaks. A shift in the peaks may also indicate recrystallization into a polymorph of Bastnaesite. Because there appeared to be stability at such high temperature we hypothesized that the sample could be back reacting during quenching. To test if this was the case we placed a closed (as opposed to the previously open sample) Bastnaesite sample in a furnace at 500°C and at atmospheric pressure. If the closed Bastnaesite sample did not decompose into the LaOF like it previously had then we could conclude that the decomposition is dependent on exposure to the atmosphere. The analysis of this sample showed that the sample still decomposed into LaOF. Therefore, we can say that the condition of a closed sample did not effect Bastnaesite's stability during the high pressure and temperature runs.

Future Work

- Conduct more trials at higher pressure/temperature in order to find where Bastnaesite decomposes and determine a more precise and complete stability curve
- Use a different buffer with the sample, other than graphite, in order to rule out the overlap between graphite and LaOF peaks on the XRD analysis. Possibilities include Nickel Oxide or Quartz Fayalite
- Conduct similar experiments with other Mountain Pass Minerals

Acknowledgements

We would like to thank Dr. Pamela Burnley in her guidance in overseeing our project. Additionally, for help in lab, we would like to thank Christopher Cline and Brandon Guttery for extensive help with using the Griggs Machine, also Yongjun Chen for the XRD, Brian Erickson for sample assembly, Christopher Adcock for the centrifuge, and May Sas and Tim Bright for various other things. Also support from the REU program of the National Science Foundation under grant DMR-1005247 is gratefully acknowledged.

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