Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18505

Humidity chambers for examining phase stability and stable isotope fractionation

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Materials and material surfaces can be unstable under atmospheric conditions at Earth's surface causing the formation of different phases. Phases such as uranium oxides can be surficially altered to form secondary phases (e.g., schoepite), and phases such as anhydrite can undergo full transformation to new OH-bearing phases (e.g., gypsum) under certain atmospheric conditions. Understanding the stability and the parameters that control stability of these phases allows us to better understand kinetic rates of phase transformations under different controlled conditions. Phase stability parameters can be combined with the chemical and isotopic compositions of materials to understand surface exchange with the atmosphere.

In this work, we describe humidity chambers that have been designed and built at Lawrence Livermore National Laboratory (LLNL) for exposing materials to different controlled atmospheric conditions. The humidity chambers allow users to control temperature, relative humidity (water concentrations), and the oxygen and hydrogen isotope composition of the water vapor in the chambers. These humidity chambers are similar to those described by Oerter et al. (2019), but have been redesigned for improved operation and coupled to several instruments for online analysis. The retrofitted chambers now allow for temperature control, stabilizing the isotopic composition of the water vapor, and monitoring the isotopic composition of the water vapor. The humidity chambers can be used in tandem with a thermogravimetric analyzer and an isotope ratio infrared spectrometer for understanding of the effects of gas compositions on mineral phases and phase surfaces. We demonstrate three applications of the humidity chamber set-up: 1) monitoring the stability of the oxygen isotope composition of goethite under different atmospheric conditions, 2) determining stable isotope fractionation between gypsum and water vapor, and 3) monitoring surface alteration of uranium-oxides.