High resolution FTIR spectroscopic characterization of hydrous K-feldspar from the Swiss Alps

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Abstract

Feldspar is the most common mineral in the Earth’s crust. Every natural feldspar contains measurable amounts of hydrogen serving as one of the largest reservoirs for water on Earth. Bound hydrogen is coupled with specific chemical impurities distinguishable through the characteristic stretching energy of the O-H hydroxyl bond. The abundance and type of hydrous impurity, incorporated into the crystal lattice during crystal growth, provide valuable insights into the thermodynamic conditions of their host geologic environment. Adularia is a mineral native to the Swiss Alps region, and its entomology is tied to the Adula Massif, a portion of the eastern Lepontine Alps. Structurally it is a low temperature (380-360°C) feldspar, and can potentially form in any alpine type hydrothermal system. Its crystal structure is similar to that of muscovite in the fact that it is partially disordered, but lacks the grid twinning of microcline. Adularia is highly ordered, and can be either a triclinic or monoclinic crystal with variable AfS1 ordering constrained into certain tetrahedral sites. Adularia is also known for its gem quality appearance, being transparent to almost translucent. This makes the mineral an excellent candidate for FTIR analysis.


Adularia (KAlSi3O8)

The samples of Adularia used to conduct this study were collected in a previous research project transect of the Swiss Alps conducted by Scott Wipperith, Todd Lindblad, Alexis Johnson, and Phillip Binger. I conducted the analysis using two separate crystal of Adularia, each displaying unique visual and FTIR results. Adularia is a mineral native to the Swiss Alpine region, and its entomology is tied to the Adula Massif, a portion of the eastern Lepontine Alps. Structurally it is a low temperature (380-360°C) feldspar, and can potentially form in any alpine type hydrothermal system. Its crystal structure is similar to that of muscovite in the fact that it is partially disordered, but lacks the grid twinning of microcline. Adularia is highly ordered, and can be either a triclinic or monoclinic crystal with variable AfS1 ordering constrained into certain tetrahedral sites. Adularia is also known for its gem quality appearance, being transparent to almost translucent. This makes the mineral an excellent candidate for FTIR analysis.

Area of Study

• The Adula Massif lies within the high-temperature Lepontine Zone of Metamorphism, as defined by Mullis et al. (2004).
• The eastern portion of Lepontine Alps from the St. Gotthard Pass to the Splügen Pass is known as the Adula Massif.

Observation of major peaks within the separate samples shows a distinct difference in absorption at certain wavelengths. Our hydrothermal feldspars exhibit similar peaks to those of low temperature igneous feldspar (microcline, Solomon and Rossman, 1988; Johnson and Rossman, 2004; Johnson, 2006). Nine observable peaks are shared in both hydrothermal and igneous feldspar absorption spectra. These peaks correspond to different chemical bonds (representing individual species of X-OH, HOH, NH4+, and organic material). Solomon and Rossman (1989) and Johnson and Rossman (2004) assigned these peaks to different contaminant species. (Right) Representative spectra of oriented microcline in the X’, Y’, and Z’ optical directions comparing igneous samples (Johnson and Rossman, 2004) to hydrothermal Adularia (this work).

• Feldspar is the most common mineral in the Earth’s crust. Although feldspar does not contain water in its stoichiometric formula, the small amounts of water incorporated into feldspar make this nominally anhydrous mineral the second largest reservoir for water on (and in) our planet.
• The small amounts of water incorporated into the crystal lattice dramatically effect the physical properties of the mineral: ppm levels of water alter a mineral’s viscosity (and thus its ability to deform) by orders of magnitude and lowers its melting temperature by hundreds of degrees. The presence of water in feldspar largely controls the evolution of the Earth’s crust.
• Conducting high resolution scans and characterizing the hydrous species of Adularia gives insight into the identity, quantity, and inter-variation of contaminant hydrous species.
• Due to the opacity of most feldspar crystals, only a handful of studies have investigated the nature of water and mineral characteristics of feldspar.

Comparing Hydrothermal to Igneous Feldspar

• There are internal variations of hydrous impurities within hydrothermal feldspar. Similar identified peaks are observed in both igneous and hydrothermal feldspar. The same hydrous species are present in both A & B hydrothermal crystals, and hydroxyl assignments may be made according to the literature. Variations in the abundance of hydrous impurities fluctuate on microscopic length scales (100 µm), and create distinct peaks and valleys in absorption scans taken across individual crystal wafers.
• Continue characterization of Adularia. Perform a series of traverses on a separate crystal where traverses are conducted from one crystal edge to the other. Explore for trends between crystal structure & orientation in relation to hydrous impurity variation.

Future Research

Internal Variation of Impurity Concentrations

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Observations & Conclusions

• There are internal variations of hydrous impurities within hydrothermal feldspar. Similar identified peaks are observed in both igneous and hydrothermal feldspar. The same hydrous species are present in both A & B hydrothermal crystals, and hydroxyl assignments may be made according to the literature. Variations in the abundance of hydrous impurities fluctuate on microscopic length scales (100 µm), and create distinct peaks and valleys in absorption scans taken across individual crystal wafers.

References


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