American Mineralogist, Volume 98, pages 1162–1171, 2013

A micro-reflectance IR spectroscopy method for analyzing volatile species in basaltic, andesitic, phonolitic, and rhyolitic glasses

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Abstract

Volatile contents of geologic glasses are used to model magma chamber and degassing processes, thus, there is considerable interest in small-scale analytical techniques for analyzing volatiles in glasses. Infrared (IR) spectroscopy has the advantage of determining volatile speciation in glasses (e.g., OH^-, molecular H_2O, molecular CO_2, and CO_3^{2-}). However, sample preparation for the most common IR method used, micro-transmission IR spectroscopy, is complicated because glasses must be prepared as thin, parallel-sided wafers. Raman analysis, while valuable for Fe-poor samples, can be difficult to use for Fe-rich glasses.

We have calibrated a micro-reflectance infrared method for determining volatile species using calculated Kramers-Kronig absorbance (KK-Abs.) spectra that requires that only one side of a glass be polished. The method is easier to use than other reflectance methods where it is difficult to determine the baseline for the IR bands. Total H_2O wt% = m·(3600 cm^{-1} KK-Abs.), where m, is the slope of the calibration line that is obtained from a fit to the data. The m value is related to the calculated refractive index, n, for a range of aluminosilicate glass compositions allowing the technique to be applied to samples with unknown calibration slopes. For calc-alkaline andesite glasses we determined calibration slopes for micro-reflectance IR measurements of molecular H_2O, molecular CO_2, and CO_3^{2-}. The method has been calibrated for glasses with up to 6.76 wt% total H_2O (but is useful for glasses with more than 20 wt% total H_2O) and has been calibrated for glasses with up to 0.575 wt% total CO_2.

This technique provides a means to analyze volatile abundances in samples that are not possible to analyze or prepare for analysis with transmission micro-IR techniques. We have determined volatile contents in fragile samples such as cracked, vesicular, or crystal-bearing glasses formed by volcanic or impact processes or in high-pressure bubble nucleation experiments and H diffusion experiments. We have monitored H uptake during weathering of basaltic glasses that cannot be polished and determined volatiles in melt inclusions and pumice.

Keywords: IR spectroscopy, glass properties, new technique, volatiles, H_2O, CO_2, CO_3^{2-}