

Accurately measuring H₂O in volcanic glasses: Application of a new FTIR spectroscopy method

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Dissolved magmatic water content changes throughout magma ascent, eruption and emplacement, and snapshots of this evolution are preserved in the dissolved water contents of volcanic glasses, which include both melt inclusions in crystals and matrix glasses in pyroclasts, dome rocks and lavas. These glasses record not only the total dissolved water content (H₂O_t), but also the water speciation, i.e. the amount of water dissolved as molecular water (H₂O_m) versus hydroxyl groups (OH). These H₂O speciation data can reveal the pressure-temperature histories of volcanic products, and are obtained using Fourier transform infrared spectroscopy (FTIR). We present here a new FTIR method that improves the accuracy, hence interpretation, of these data, and highlight its potential for reconstructing the original H₂O_t contents of hydrated glasses.

Mid-IR FTIR analyses of volcanic glasses must use the 3500 cm⁻¹ H₂O_t and 1630 cm⁻¹ H₂O_m peaks, with OH concentration found indirectly as $OH = H_2O_t - H_2O_m$. However, large errors in H₂O_t and OH concentrations can occur due to the use of a fixed 3500 cm⁻¹ H₂O_t molar absorptivity coefficient (ϵ_{3500}), when ϵ_{3500} in fact varies with H₂O speciation. Our new method is a modification of the Beer-Lambert law (which converts absorbance into concentration) that accounts for the species-dependence of ϵ_{3500} . This method requires no special equipment or procedure, and can also be used to reprocess existing data.

We demonstrate the improved accuracy of H₂O data obtained using this method, and present applications including H₂O diffusion profiles, melt inclusions, and hydrated glasses. FTIR (unlike other techniques that measure only H₂O_t) can identify hydrated glasses by their elevated H₂O_m contents, since low temperature hydration adds the diffusive species H₂O_m without altering OH. This 'disequilibrium' speciation makes the species-dependent ϵ_{3500} method critical for hydrated glasses. Moreover, by combining accurate OH contents of such glasses with existing models of H₂O speciation, we show that it is possible to reconstruct their original, pre-hydration H₂O_t contents.