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Analyzing water contents in unexposed glass inclusions in quartz crystals

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Abstract

Fourier-transform infrared (FTIR) spectroscopy is commonly used to measure volatile contents dissolved in glass inclusions in minerals. The standard method is to doubly polish the crystal to fully expose the inclusion to allow infrared light to pass through the inclusion only. Glass inclusions are often a few tens of micrometers thick, which can limit the usefulness of FTIR because of how fragile samples become when thinned enough to doubly expose inclusions. Here, we test whether unexposed inclusions can be feasibly analyzed by measuring the dissolved volatile contents of a population of rehomogenized quartz-hosted glass inclusions at variable exposure levels. We analyzed 118 unexposed inclusions in 46 crystals. Of those, we analyzed the 74 inclusions in 38 crystals that survived being singly exposed. Of those, only 24 inclusions in 18 crystals remained to be analyzed when doubly exposed. Measuring the path length of light through the inclusion is critical to FTIR analyses. That length can be measured directly for doubly exposed inclusions. For those inclusions we find that water contents vary from 1.6 to 2.6 wt%, averaging 2.2 ± 0.3 wt%. Path length is difficult to measure, however, in singly exposed or unexposed inclusions. Indeed, we find that path length is variably underestimated when measured using a well-calibrated optical method. Despite that difficulty, the average water contents for the populations at each exposure level are statistically the same. But, on an inclusion-by-inclusion basis volatile contents at various exposure levels are highly discrepant because the typically underestimated thicknesses for non-doubly exposed inclusions result in anomalously high volatile contents. One way to measure path length in those inclusions is to reorient the host crystal to align the path length horizontally so it can be measured with the eyepiece reticle. Often, however, that technique proves impractical because small samples are difficult to handle. When path length cannot be measured directly, we find that using the average of the dimensions of the inclusion orthogonal to the path length can be used as a proxy for path length. That proxy allows volatile contents in unexposed inclusions to be analyzed accurately, which significantly reduces difficulties of sample preparation and can dramatically increase the number of potential target inclusions.

Keywords: Glass inclusion, FTIR, volatiles, water content, CO_2 content