How do quartz watches compare?: glass inclusion faceting versus Ti diffusion profiles

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Constraining the timescales over which magma bodies accumulate and erupt is critical to developing methods to effectively monitor and prepare for future eruptions. There are many methods used to assess timescales (radiometric dating, geospeedometry, textural analysis), but results often conflict, and our ability to directly compare timescales obtained from different methods is debated. Here we assess the use of glass inclusion faceting as a geospeedometer. Glass inclusions change from rounded to increasingly faceted over time at magmatic temperatures through dissolution and re–precipitation. Thus, the degree of faceting is a possible measure of residence time. Our prior work on faceting revealed residence times that compare well with those suggested by other methods; however, the results depend on crude estimates of critical parameters such as size, shape, and position of inclusions using optical microscopy. We have started using propagation phase contrast x–ray tomography, which enhances object edges, to image glass inclusions within quartz crystals. We use image processing techniques to find a 3D hull that envelopes the inclusion, and we fit an equal volume ellipsoid to the hull. We compute the volume diffused during faceting as the volume of the ellipsoid that protrudes from the inclusion hull. We also assess size and position of the inclusion within the crystal. This improved characterization allows a more critical evaluation of the applicability of glass inclusion faceting as a measure of residence time. We compare results from glass inclusion faceting with those from diffusional relaxation of Ti in quartz. Variations in cathodoluminescence (CL) intensity correlate well with variations in Ti contents in quartz, so we use CL profiles as a proxy for Ti zoning. We employ a 1D diffusion model along selected CL profiles to find the best fit relaxation length scale, from which we can calculate residence times–taking advantage of experimentally determined diffusion coefficients for Ti in quartz. We are documenting textures of multiple glass inclusions located in distinct zones within quartz crystals to directly compare timescales from faceting and diffusional relaxation. We obtain tomograms of quartz crystals containing inclusions at GSECARS (Advanced Photon Source). We then select grains with multiple inclusions, particularly those with inclusions near the center (along the c axis) of the crystal, which we polish and image with SEM-based panchromatic CL. We have so far imaged crystals from 5 pumice clasts of different compositions of the 240 ka Ohakuri–Mamaku ignimbrites (Taupo Volcanic Zone, New Zealand). Results from the two methods are comparable, lending support to faceting as a geospeedometer. Both methods suggest these magma bodies were short lived, crystallizing over 10s–100s of years prior to eruption, consistent with recent results obtained for crystallization timescales of other giant magma bodies (e.g. Bishop Tuff).