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Improved volatile quantification in unexposed quartz-hosted melt inclusions by FTIR spectroscopy and an application to the Toba Caldera Complex, Sumatra (Indonesia)

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Melt inclusions hosted in mineral phases present unique opportunities to study magma storage conditions at the time of inclusion entrapment (e.g. pre-, syn- volatile contents, melt compositions, and pressure). Quartz-hosted melt inclusions are particularly suitable for studying the late-stage evolution of large silicic reservoirs in the shallow upper crust and obtain information about reservoir's growth, longevity and eruption styles. We studied the volatile concentrations in melt inclusions from three Quaternary caldera-forming eruptions in the Toba Caldera Complex (Sumatra, Indonesia): the Youngest Toba Tuff (YTT; ~74 ka), the Middle Toba Tuff (MTT, ~501 ka) and the Oldest Toba Tuff (OTT, ~840 ka). We adopted the method of [1] which used transmission Fourier Transform Infrared (FTIR) spectroscopy to quantify volatile contents (H2O and CO2) in unexposed, single polished quartz-hosted melt inclusions. We performed a series of experiments and have successfully extended the applicability of this method to melt inclusions embedded within thicker quartz (e.g. a diameter of c.a. 60 μm inclusion embedded in its host quartz of 1 mm) while obtaining similar precision to transmission mode measurements on melt inclusions that are exposed on both sides. The estimated volatile contents range between 5.0–6.2 w.t% H2O and 0–300 ppm CO2 for YTT, 4.8–6.3 w.t% H2O and <100 ppm CO2 for MTT, and 4.6–5.5% w.t% H2O and <100 ppm CO2 for OTT. Our data for all three eruptions indicate that the H2O content is ~ 0.5–1.0 w.t.% higher than previously observed [2] while a higher CO2 content is found only in YTT. Our findings suggest that the YTT magma reservoir could have resided at a pressure of ~200 MPa, while the MTT and OTT magmas could have ponded at shallower depths (~150 MPa) before eruption.

[1] Tollan, P. et al. (2019). Assessing magmatic volatile equilibria through FTIR spectroscopy of unexposed melt inclusions and their host quartz: A new technique and application to the Mesa Falls Tuff, Yellowstone. Contrib. Mineral. Petrol., 174(3), 24.

[2] Chesner, C. A., & Luhr, J. F. (2010). A melt inclusion study of the Toba Tuffs, Sumatra, Indonesia. J. Volcanol. and Geotherm. Res., 197(1), 259–278.