Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36853

Could CO_2 be used for volcano monitoring in Tāmaki Makaurau Auckland, Aoteaora New Zealand?

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There is a 10% likelihood of eruption in the next 50 years from the Auckland Volcanic Field (AVF) underlying Tāmaki Makaurau Auckland, Aotearoa New Zealand's largest city. Volcano monitoring for the AVF currently relies on detecting seismicity from magma ascent, which may provide as little as a few days' warning. A complementary method is detecting precursory CO_2 emissions, which may provide a longer warning period due to the low solubility of CO_2 in magmas and therefore its early (deep) exsolution. For volcano monitoring using CO_2 emissions to be feasible, the CO_2 must be released ahead of the magma in sufficient quantities to be detected above urban CO_2 emissions.

As there has not been a modern eruption to test this approach on, we must rely on older AVF eruptions for which we only have the final erupted products to analyse. Hence, we must assess how much CO_2 was released from previous AVF eruptions and whether degassing occurred under open-system conditions. The maximum CO_2 concentration measured in melt inclusions can be used to estimate the initial CO_2 content of the magma; whilst the co-variation of CO_2 concentration and isotope ratio during degassing can easily differentiate between open- and closed-system degassing. Hence, we analysed olivine-hosted melt inclusions from the most recent AVF eruption at Rangitoto volcano via secondary ion mass spectrometry to measure carbon isotopes and CO_2 concentrations. Melt inclusions were rehomogenised in a piston-cylinder prior to analysis to dissolve melt inclusion-hosted bubbles back into the melt. This enabled measurement of the total CO_2 budget of the melt inclusion from only analysing the glass. We then modelled CO_2 emissions during magma ascent using thermodynamic degassing models.

Our results show that Rangitoto magmas released large quantities of CO_2 under open-system degassing trends deep in the sub-surface, establishing CO_2 flux monitoring as the earliest warning indicator of magmatic ascent and future volcanic unrest. With new measurements and modelling of natural and anthropogenic CO_2 fluxes, we expect to be able to detect these volcanic emissions for volcano monitoring in the future.