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Insights into eruption precursors: linking the petrological and geophysical record

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Active volcanoes are monitored through a variety of geophysical techniques including GPS, satellite based radar (InSAR), gas emissions, ground deformation and seismicity to detect signs of unrest. A time series of these geophysical processes, can thus be constrained that may for example provide a record of the magma ascent, the deflation or inflation of a magma body. Conversely, crystals hosted in the magma body provide a direct record of the magmatic processes experienced during its growth as the magma evolved. Perturbations within the magmatic system often result in renewed crystal growth of a different composition that result in highly zoned crystals. Each discrete zoned can be geochemically fingerprinted by in-situ microanalytical techniques such as electron probe microanalyser (EPMA) and scanning electron microscope (SEM) to identify the magmatic process(es) responsible for the generation of these crystals. Combining this knowledge from multiple crystals within a single eruption or unit allows the evolution of the magmatic system to be unravelled and pieced together. Importantly, the timescales of these processes can be assessed through the chemical relaxation of chemical gradients across the compositional zones through diffusion techniques. This permits an independently constrained petrology time series to be constrained that can be combined with the geophysical time series providing insights into magmatic processes that occur prior to eruption.

However, this approach to link both a petrological and geophysical time series of an active volcano requires a relatively rare and unique set of circumstances. Not only must the volcano be active, it must have a good geophysical record extending at least 10-20 years, have a well characterised recent eruption with zoned crystals for which the relevant diffusion coefficients are known to allow access to the samples. One such eruption is the 2010 Eyjafjallajökull. The summit eruption was preceded by an effusive flank eruption at Fimmvörduháls from the 20th March-12th April. Here we present a petrological time series constrained from diffusion modelling of olivine crystals and compare it to the geodetic and seismicity recorded