Linking petrology and volcano monitoring data at active arc volcanoes

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Many active volcanoes worldwide are continuously monitored through a variety of methods, such as seismicity, gas flux, and ground deformation that look for signs that may indicate an impending eruption. These monitored signals provide a real-time record of the current state of the volcano. One of the enduring volcanological challenges is how to relate these signals to magmatic processes beneath the volcano. However, timescales of magmatic processes prior to eruption are poorly constrained, but may be a key to our understanding of active volcanic systems.

Petrological methods allows us to interrogate recent volcanic eruptions and compare those to the monitoring record. As a result, we are able to examine the relative timing of monitored precursors to an eruption. Zoned volcanic crystals potentially preserve a record of the changing magmatic conditions within their crystal structure. As magma evolves, changes in temperature, volatile content, pressure or composition result in renewed growth of a different composition generating zoned crystals. Diffusion chronology enables timescales of magmatic processes to be calculated. Using known eruption dates, this petrological timeseries can be correlated to monitoring data to constrain pre-eruptive processes.

Case studies from Mount St. Helens (MSH), USA and Mt. Ruapehu, New Zealand will be presented. Pyroxene crystals from both of these volcanoes have been investigated through a combination of back-scattered electron images and major element chemistry using electron probe microanalyser. At MSH and Ruapehu, over 500 pyroxene crystals were investigated and revealed multiple crystal populations. Diffusion chronometry from MSH show that rims grew within two years prior to eruption, many within months of eruptions. Peaks in crystallisation correlate with peaks in seismicity and SO2 flux, providing evidence for a relationship between seismicity and the arrival of new magma pulses into the magma chamber. Diffusion chronometry of clinopyroxene at Mt. Ruapehu indicate peaks in crystallisation 4-5 months prior to eruption that correlate with changes in the geochemistry of Crater Lake. Results from these studies provide evidence that time-series information locked up in zoned volcanic crystals can be used to assess precursory activity of past eruptions. In turn this information can be used to better evaluate monitoring signals at active volcanoes.