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How to integrate petrology and magma process time scales with geophysical and geochemical volcano monitoring data?

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Recent technological advances including remote sensing by satellites, seismic networks, and gas spectrometers allow now monitoring of active volcanoes in real time and with an unprecedented level of detail. Time series analyses of such new datasets have allowed the forecasting of eruptive activity in the short term (e.g., weeks or months). Notwithstanding these technical advances, volcano monitoring is still typically an exercise of acquiring large data sets and looking for empirical correlations between various measurements with very limited insight to the mechanisms that cause such signals. In addition, such real-time but short term monitoring datasets do not allow for making longer term estimations (years to decades) of unrest of dormant volcanoes.
There now exist a number of highly sophisticated techniques of rock nano and microanalysis, which, when combined with experimental calibration and numerical models, may allow to move towards a more process-based eruption forecasts. For example, phase equilibria on erupted rocks can be used to determine the depth and volatile content of the storage magma region, and such information should be related to the deformation signals recorded by satellite or ground GPS or tilt measurements. A more recently developed opportunity to link the processes occurring at depth and those recorded at the surface is through detailed geochemical and textural studies of the glass and mineral zoning. Modeling the compositional heterogeneities in glasses and crystals can be exploited to recover the time since various processes occur prior to (e.g., magma mixing) or during eruption (e.g., degassing) and in this way help to better interpret the monitoring signals. Several examples about how to relate petrological information with monitoring data from Mt Etna, Mt St Helens and other volcanoes will be discussed in the presentation.